# CHAPTER 3 - AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

## 3.1 INTRODUCTION AND BACKGROUND

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

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

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

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

Consistent with the Council on Environmental Quality's Implementing Regulations for NEPA (40 Code of Federal Regulations [C.F.R.] § 1502.16), adverse environmental effects that cannot be avoided, the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources involved in implementation, are presented in separate sections at the end of this chapter.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

### 3.1.1 Assumptions

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

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

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

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

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

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

### 3.1.2 Resources Screened from Further Analysis

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

### 3.1.3 Summary of Environmental Consequences

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

**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. | 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.<br>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. | 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.<br>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. | 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.<br>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.<br>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. | 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.<br>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. |

| Resource | NAA | MO1 | MO2 | MO3 | MO4 |
|---|---|---|---|---|---|
| River Mechanics | Negligible change | Minor change in depositional patterns with temporary head-of-reservoir deposits shifting downstream into Lake Roosevelt, although available deposit volume is limited.<br>Minor decrease in the amount of sediment passing the Clearwater River at the confluence of the Snake and Clearwater Rivers.<br>Minor amount of coarsening of bed sediment at the head of Lake Roosevelt.<br>Minor (less than 1% change) in average annual volume of sediment depositing in the Snake River FNC and LCR FNC.<br>For the other metrics, the effects would be negligible. | Minor change in depositional patterns with temporary head-of-reservoir deposits shifting downstream into Dworshak Reservoir.<br>Minor amount of coarsening of bed sediment at the head of Lake Roosevelt.<br>Minor (less than 1% change) in average annual volume of sediment depositing in the Snake River FNC and LCR FNC.<br>For the other metrics, the effects would be negligible. | 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.<br>Potential for a major increase in the amount of sediment passing downstream of the Snake River into the Columbia River above McNary.<br>Potential for major increase in amount of material depositing in McNary Reservoir.<br>Dredging would stop in the lower Snake River. Minor increase in average annual volume of sediment passing into the lower Columbia below McNary.<br>Effects at the remaining storage project would be negligible. | 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.<br>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.<br>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.<br>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. |

| 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.<br>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.<br>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.<br>Negligible to minor overall water quality effect in Region B, with the exception of major reductions in TDG below Grand Coulee Dam.<br>Major short-term adverse effect on water quality due to the mobilization of sediment during dam breaching.<br>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.<br>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 to 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 | Minor effect to wildlife, vegetation, and wetlands associated with operation of Libby Dam. and negligible effect for other areas in Region A.<br>Minor adverse effect to wildlife habitat and wetland vegetation for Lake Roosevelt. Negligible effects to other areas in Region B.<br>Minor (Dworshak) and negligible change (lower Snake River) to habitat, vegetation, and wildlife in Region C.<br>Negligible effect to habitat, vegetation, and wildlife in Region D.<br>Negligible effects on floodplains in Regions B and C, with minor effects in Region A and D below Bonneville Dam.<br>For special status species, there would be negligible effects. | Moderate effects to Region A.<br>Minor effect to vegetation, wetlands, habitat, and wildlife in Lake Roosevelt. Negligible effect in other locations in Region B.<br>Negligible effects in Regions C. Minor effects in Region D.<br>Minor effects on floodplains in Regions A and B. Negligible in Region C, with minor effects in Region D below Bonneville Dam.<br>For special status species, there would be negligible effects. | Moderate adverse effect on wetlands, vegetation, habitat, and wildlife in Region A.<br>Negligible effects in Region B.<br>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.<br>Negligible effects in Region D.<br>Negligible effects on floodplains in Regions A, B, and D, with major beneficial effects in Region C below Dworshak Dam.<br>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. | Moderate adverse effect on wetlands, vegetation, habitat, and wildlife in Region A and D.<br>Minor effect in Regions B.<br>Negligible effects on wildlife and habitats in Region C.<br>Moderate effects on floodplains in Regions B and C, with minor effects in Region D below John Day Dam.<br>For special status species, there would be negligible effects. |
| Power Generation and Transmissio n | 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. | 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. | Long-term, moderate beneficial effects on system reliability. 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. | 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. | 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. |

| 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.<br>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 Managemen t | 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 Transportati on | 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<br>High estimate = $1,161 million | Low estimate = $897 million<br>High estimate = $1,002 million | Low estimate = $1,000 million<br>High estimate = $1,105 million |

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 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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## 3.2 HYDROLOGY AND HYDRAULICS

### 3.2.1 Introduction and Background

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

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

#### *3.2.1.1 Columbia River Basin Description*

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

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

Major tributaries of the Columbia River include the following:

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

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

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

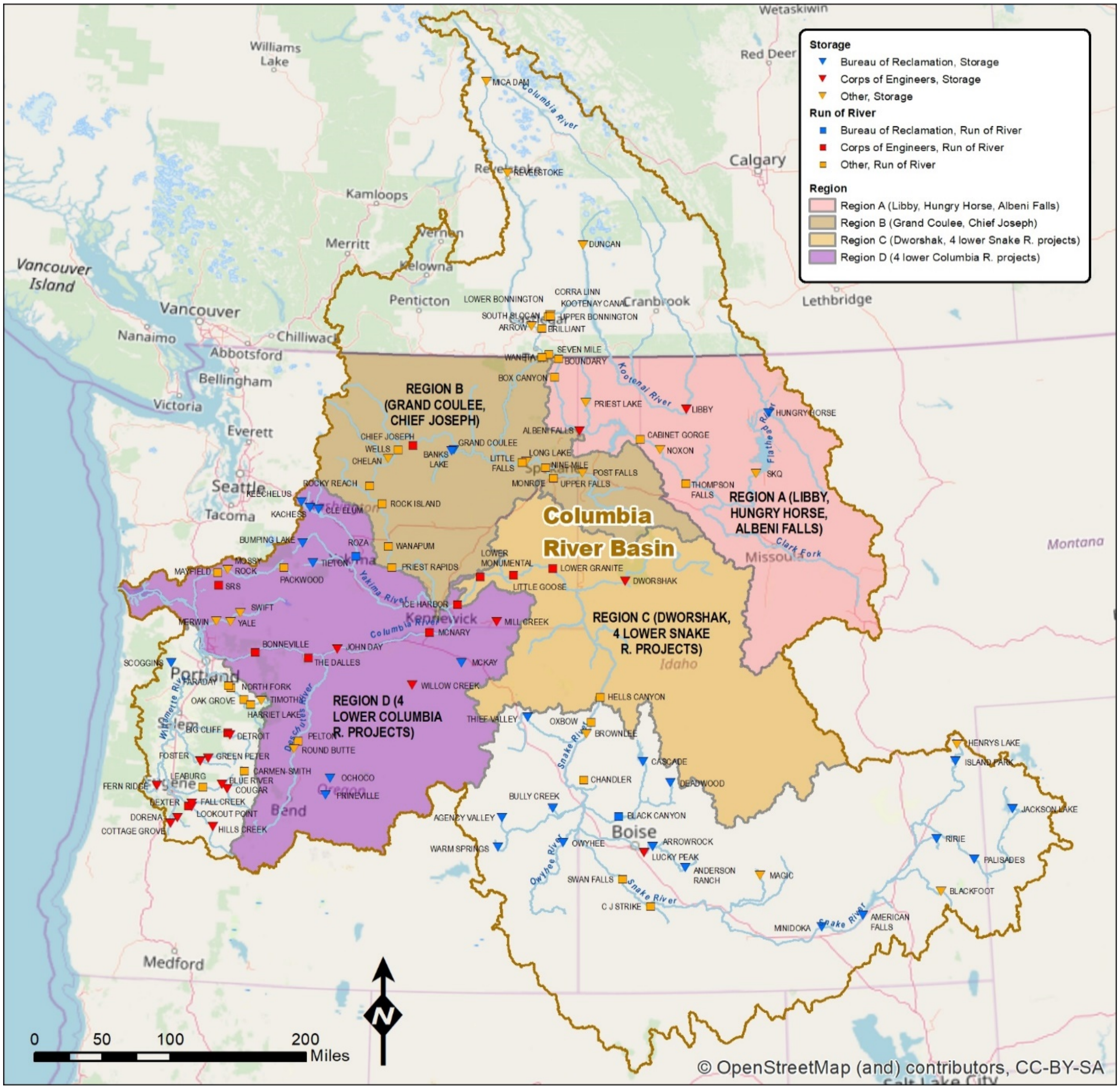



**Figure 3-1. Columbia River Basin**

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

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

#### *3.2.1.2 Columbia River Basin Climate*

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

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

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

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

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

### 3.2.2 Area of Analysis

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

#### *3.2.2.1 Columbia River Basin Region Descriptions*

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

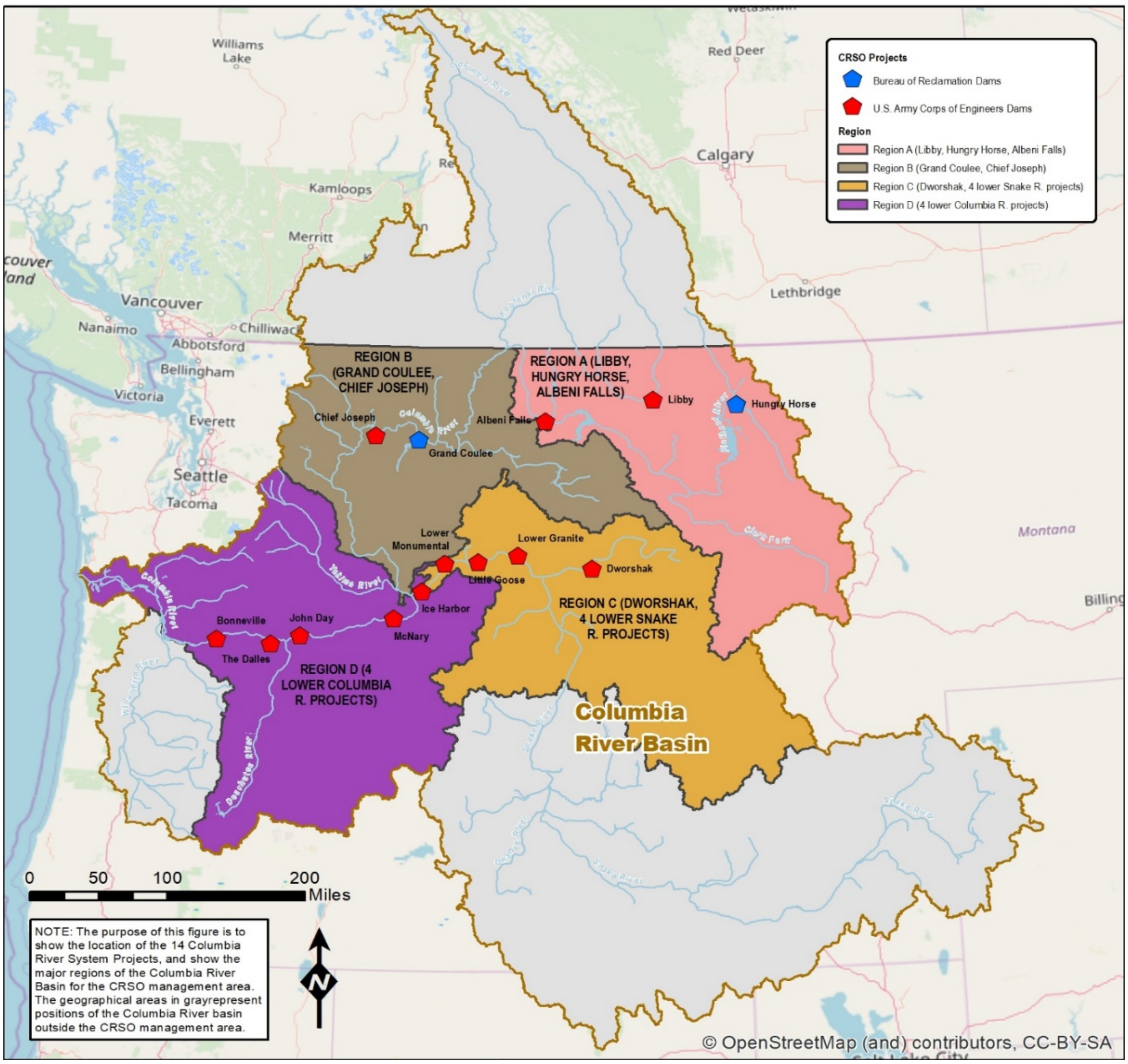



**Figure 3-2. Columbia River Basin Regions (Regions A, B, C, and D)**

**REGION A**

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

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

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

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

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

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

**REGION B**

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

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

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

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

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

**REGION C**

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

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

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

**REGION D**

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

The reach of the Columbia River from Priest Rapids Dam to Bonneville Dam, most of which is in Region D, is approximately 250 river miles long. The contributing drainage area to the reach is approximately 38,150 square miles. The landscape is diverse, with the Cascade Range on the west; the Blue, Wallowa, and Ochoco Mountains along the south and east; and the Columbia River Plateau defining the middle and northern portion of the drainage area. Five major tributaries join this reach: the Deschutes River, Snake River, John Day River, Umatilla River, and Yakima River.

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

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

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

### 3.2.3 Affected Environment

#### *3.2.3.1 Reservoir System*

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

A figure depicting the range of flows at The Dalles is provided in Figure 3-3, with an overlay of unregulated and observed (regulated) flows from water year 2017. The average annual flow volume at The Dalles is 134 Maf, and the average annual flow is approximately 185,000 cfs[2]. The term “unregulated” is used to describe what the runoff in the river would be without dams[3]. From the figure depicting the range of flows at The Dalles, an annual recurring pattern can be seen, with peak flows occurring in late spring. The figure also shows that during the late spring and early summer, the range of flows between the minimum and maximum lines is greater than any other time of year. This means that there is more variability in natural flows in the system during this time of year than at any other time. The overlay of observed flows for water year 2017 shows the effect of regulation by storage dams in the system. Water year 2017 had a 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.

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

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

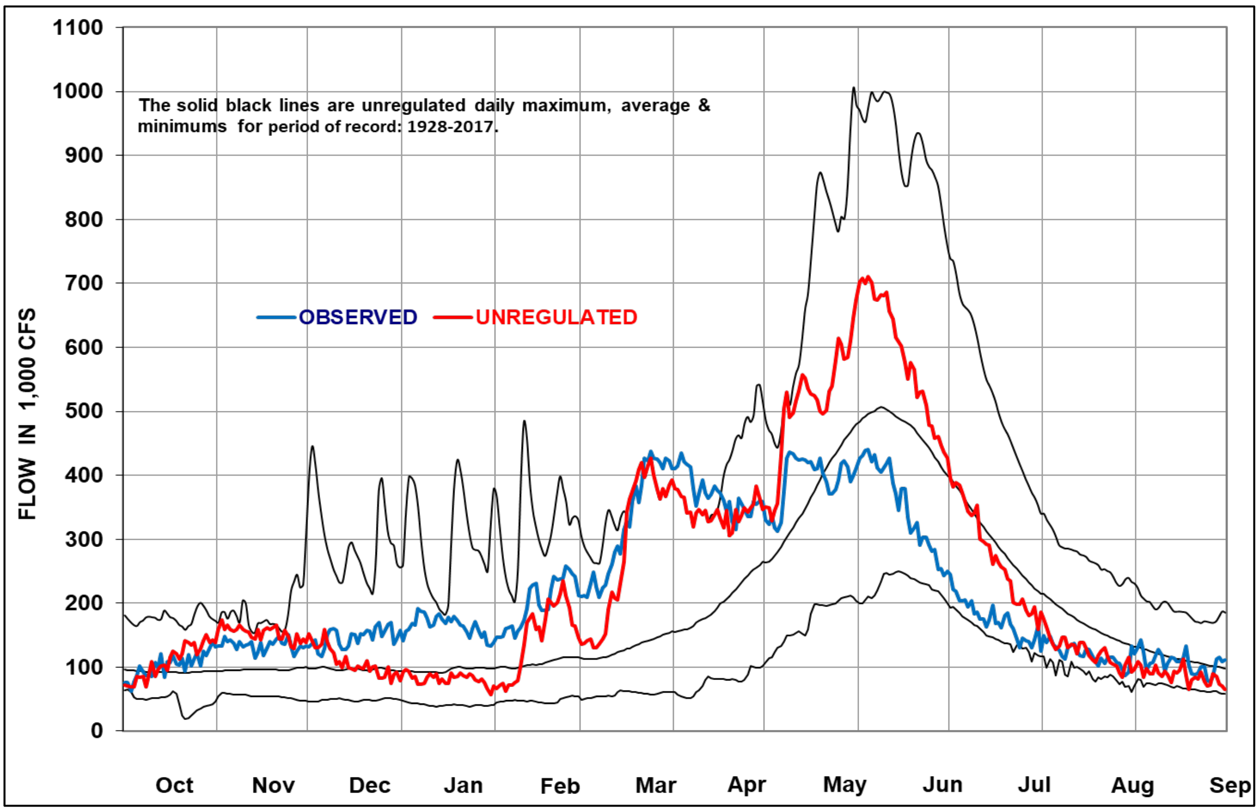



**Figure 3-3. Columbia River Stream Flows as Measured at The Dalles, Oregon, October 2016–September 2017**

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

#### *3.2.3.2 Water Levels Between Projects*

Water levels throughout this system are strongly influenced by the many dams, to the extent that the water surface profile throughout the study area can largely be described as a series of reservoirs. There are only a handful of relatively steep stretches of river that are above the influence of a downstream dam and/or reservoir. Figure 3-4 shows water surface profiles for most of the major rivers evaluated in this study for changes in water levels. The rivers are divided into hydraulic reaches, each of which has an assigned reach number, and they are shown here to introduce the reader to the numbering convention and geographic extent of each reach. Several technical teams involved with CRSO EIS environmental consequences evaluations use this reach numbering system to describe effects that would be associated with the various MOs.

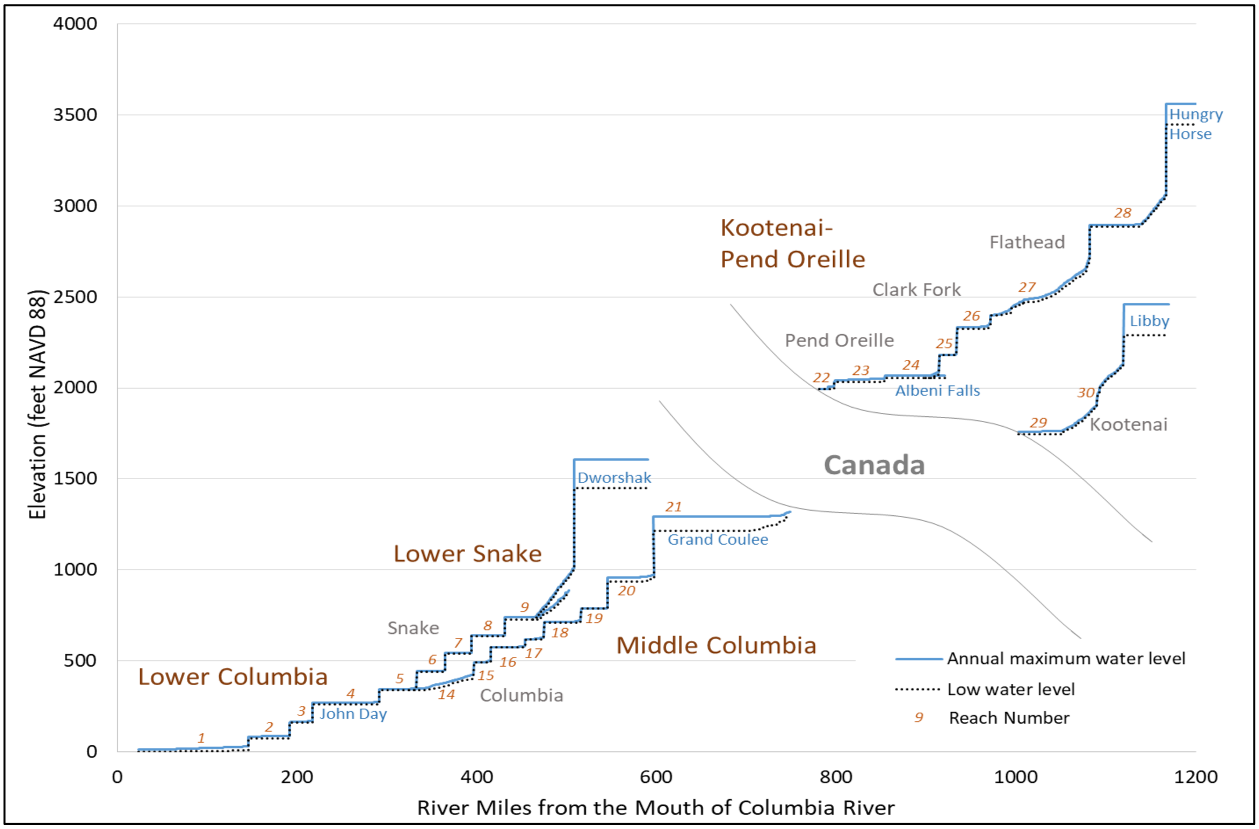



**Figure 3-4. Water Surface Profiles for the Columbia River System Hydraulic Model Reaches**

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

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

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

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

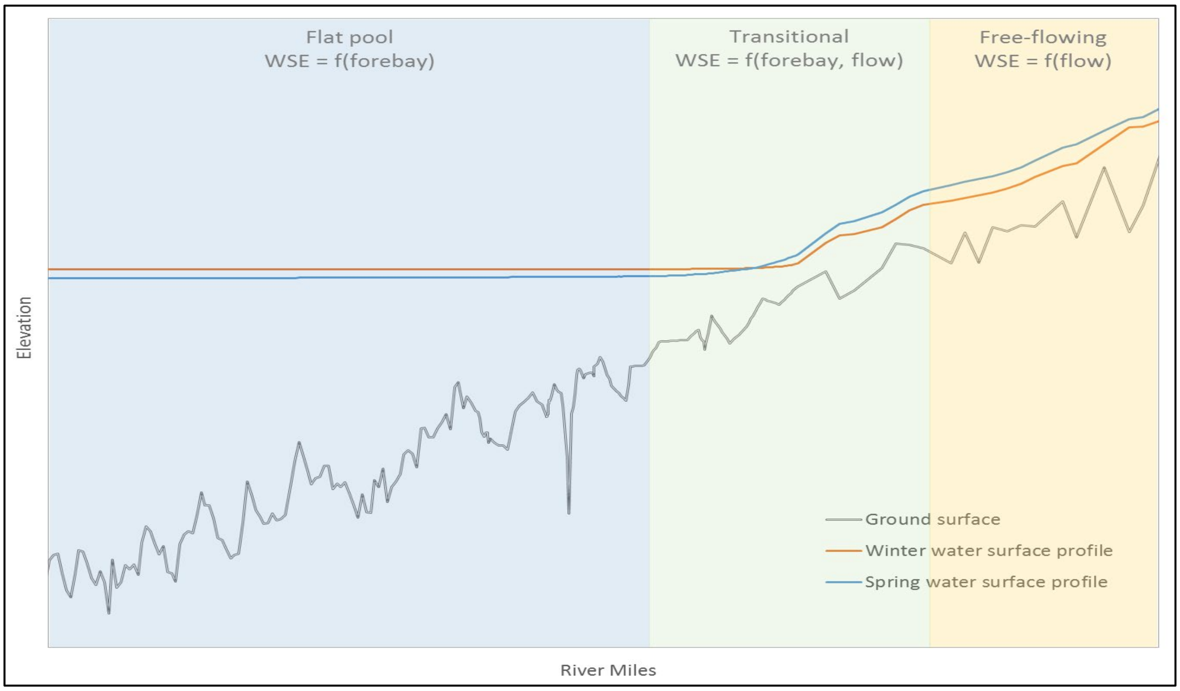



**Figure 3-5. Water Surface and Ground Surface Profiles of Typical Hydraulic Reach, and the Three Zones of Influence**

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

**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<br>Kootenai RM 157 to 219 | Entire reach is free-flowing, i.e., above influence of Kootenay Lake downstream.<br>Includes Kootenai Falls (Kootenai RM 191) |
| | R29 | Crossport, Idaho, to U.S.-Canada Border<br>Kootenai RM 103 to 157 | Water levels influenced by Kootenay Lake, especially below Bonners Ferry, Idaho (RM 150). |
| | R28 | Hungry Horse to SKQ<br>Flathead RM to 79 to 158 includes Whitefish River | Reach begins at bottom of Flathead Lake (RM 79.437) above constriction above SKQ Dam.<br>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.<br>Free-flowing reaches exist above roughly RM 133 on the Flathead River and RM 3 on the Whitefish River. |
| | R27 | SKQ to Thompson Falls<br>Clark Fork RM 72 to 110 and Flathead RM 0 to 74 | Thompson Falls is a run-of-river dam.<br>Free-flowing reach along both Clark Fork and Flathead reaches. |
| | R26 | Thompson Falls to Noxon<br>Clark Fork RM 35 to 72 | Flat pool may occur during low-flow periods. |
| | R25 | Noxon to Cabinet Gorge<br>Clark Fork RM 15 to 34 | This run-of-river reservoir extends the length of the reach.<br>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<br>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<br>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.<br>There is a major constriction around RM 25.8 that can produce a relatively sharp jump in water surface elevations during high-flow conditions. |

| 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<br>Columbia RM 597 to 748 | Roosevelt Lake operation can change pool levels by 50 to 80 feet annually.<br>Flat pool can be assumed for 100 to 130 miles above the dam, depending on the season. |
| | R20 | Grand Coulee to Chief Joseph<br>Columbia RM 546 to 597 | This run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R19 | Chief Joseph to Wells<br>Columbia RM 516 to 546 | This run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R18 | Wells to Rocky Reach<br>Columbia RM 475 to 515 | This run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R17 | Rocky Reach to Rock Island<br>Columbia RM 454 to 475 | This run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R16 | Rock Island to Wanapum<br>Columbia RM 415 to 453 | This run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R15 | Wanapum to Priest Rapids<br>Columbia RM 397 to 415 | This run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R14[2/] | Priest Rapids to Richland, Washington<br>Columbia RM 335 to 397 | Sometimes referred to as the “Hanford Reach,” this reach is mostly free-flowing.<br>The lower few miles can be influenced by Lake Wallula above McNary Dam. |

| 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.<br>Reservoir levels can influence Snake River water levels as far RM 145, 10 miles upstream of the confluence with the Clearwater.<br>Free-flowing reach on the Clearwater River starts about 5 miles above confluence with Snake River. |
| | R08 | Lower Granite to Little Goose<br>Snake RM 70 to 106 | This mostly run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R07 | Little Goose to Lower Monumental<br>Snake RM 41 to 69 | This mostly run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R06 | Lower Monumental to Ice Harbor<br>Snake RM 9 to 40 | This mostly run-of-river reservoir extends the length of the reach.<br>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.<br>Includes Snake and Yakima River reaches for a short distance above their confluences with the Columbia.<br>A flat pool can extend from the dam for 20 to 40 miles depending on flow conditions. |
| | R04 | McNary to John Day<br>Columbia RM 217 to 291 | Reservoir mostly run-of-river but pool can fluctuate over 10 feet.<br>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<br>Columbia RM 192 to 217 | Mostly run-of-river reservoir extends the length of the reach.<br>Flat pool may occur during low-flow periods. |
| | R02 | The Dalles to Bonneville<br>Columbia RM 146 to 191 | Mostly run-of-river reservoir extends the length of the reach.<br>Reach is relatively channelized with a notable constriction a couple of miles above dam (~RM 147). |
| | R01 | Below Bonneville<br>Columbia RM 30 to 146 | Free-flowing reach from Bonneville Dam (RM 146) to RM 30 near Tongue Point, Oregon.<br>Includes Willamette River below Oregon City Falls (RM 26), Cowlitz River below Castle Rock, Washington (RM 19) and other smaller tributaries.<br>Tidal influence extends all the way to Bonneville Dam and partially up the major tributaries. |

Note: RM = river mile.
1/ Reach 30 is combined with Reach 29 in hydraulic model “R29_30” or just “R29”.
2/ Reach 14 is combined with Reach 5 in hydraulic model “R5_14” or just “R05”.

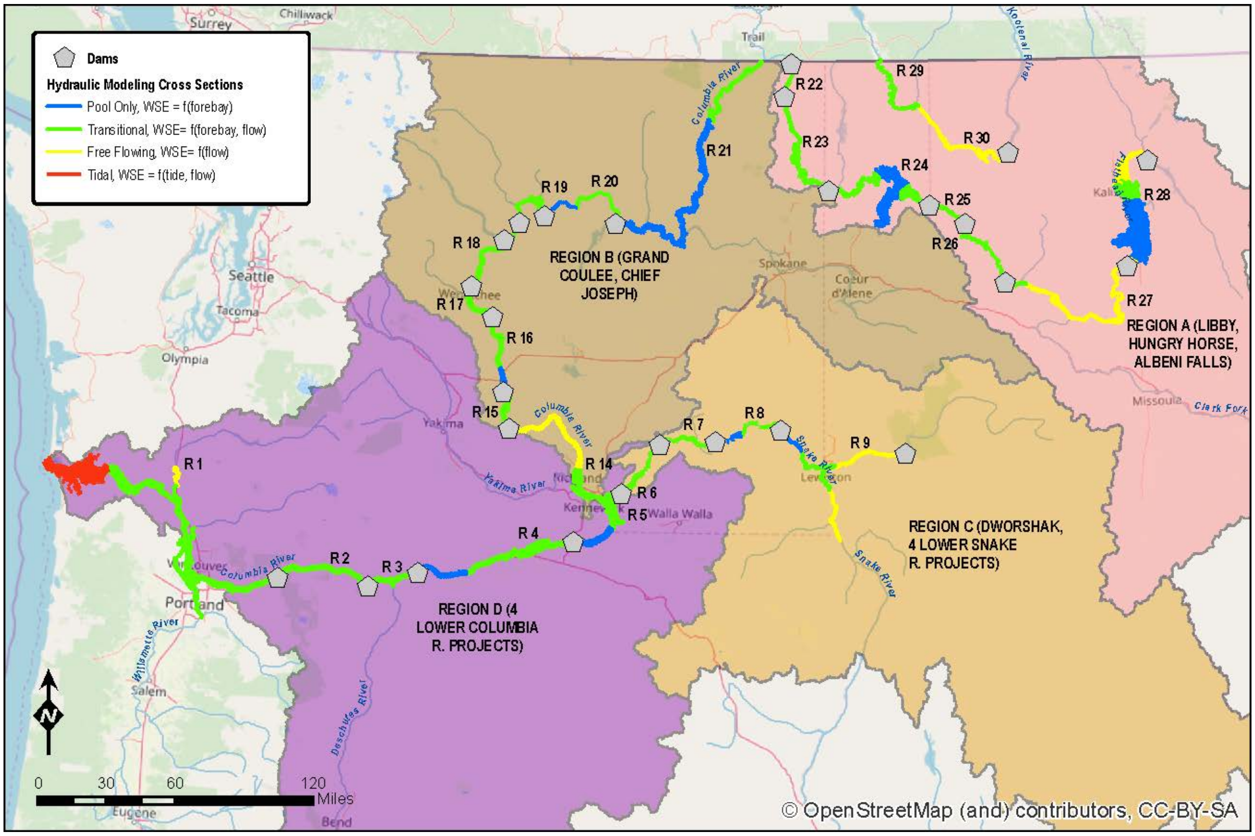



**Figure 3-6. Map of Hydraulic Reaches Showing the Zones of Influence**

Note: WSE = water surface elevation. Flat pool (blue); free-flowing (yellow); transitional (green); Reach 1, which is tidally influenced, is shown in red.

### 3.2.4 Environmental Consequences

#### *3.2.4.1 Methods*

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

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

The ResSim model provided FRM constraints as inputs to the HYDSIM model. Conversely, the HYDSIM model provided the Columbia River Treaty operation for the Canadian projects to ResSim. In addition, HYDSIM modeling provided the lack-of-market information that was layered on the ResSim output to provide daily spill flow. Since both models produced flows and elevations for the CRS projects, their outputs were compared to verify that they were providing similar results. Details of how the models worked together are described in Appendix I, *Hydroregulation Appendix*. The CRS ResSim Model is the last modeling step from which daily flow and reservoir elevations are taken for analysis and use by other technical teams. While operations important for determining water conditions on a seasonal and even daily basis are generally modeled, certain operations such as load shaping or turbine preference are not captured in the model.

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

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

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

Computer hydroregulation modeling is conducted for planning studies in which operational scenarios, or rules, are tested over many years of data. Each alternative has a fixed rule set, so that when the model is computed each event is handled with the same rule conditions without human interference to prefer different conditions. Real-world reservoir operation is complex; different information is available to the water manager for decision making, and decisions are shaped by an individual water manager's experience and risk tolerance. Water managers also adapt operations, as possible within constraints, to an operation that meets the goals of system users given the specific conditions of that particular water year[5]. Operation changes of this nature are not possible to represent in a planning model, nor are they desirable, as they would make comparing different MOs substantially more challenging and likely skew the results 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).

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

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

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

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

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

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

**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 ≤ 20 | ≤1,931 | ≤1,433 | ≤5,096 | ≤71,462 |
| Average | 20 < p ≤ 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 |

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

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

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

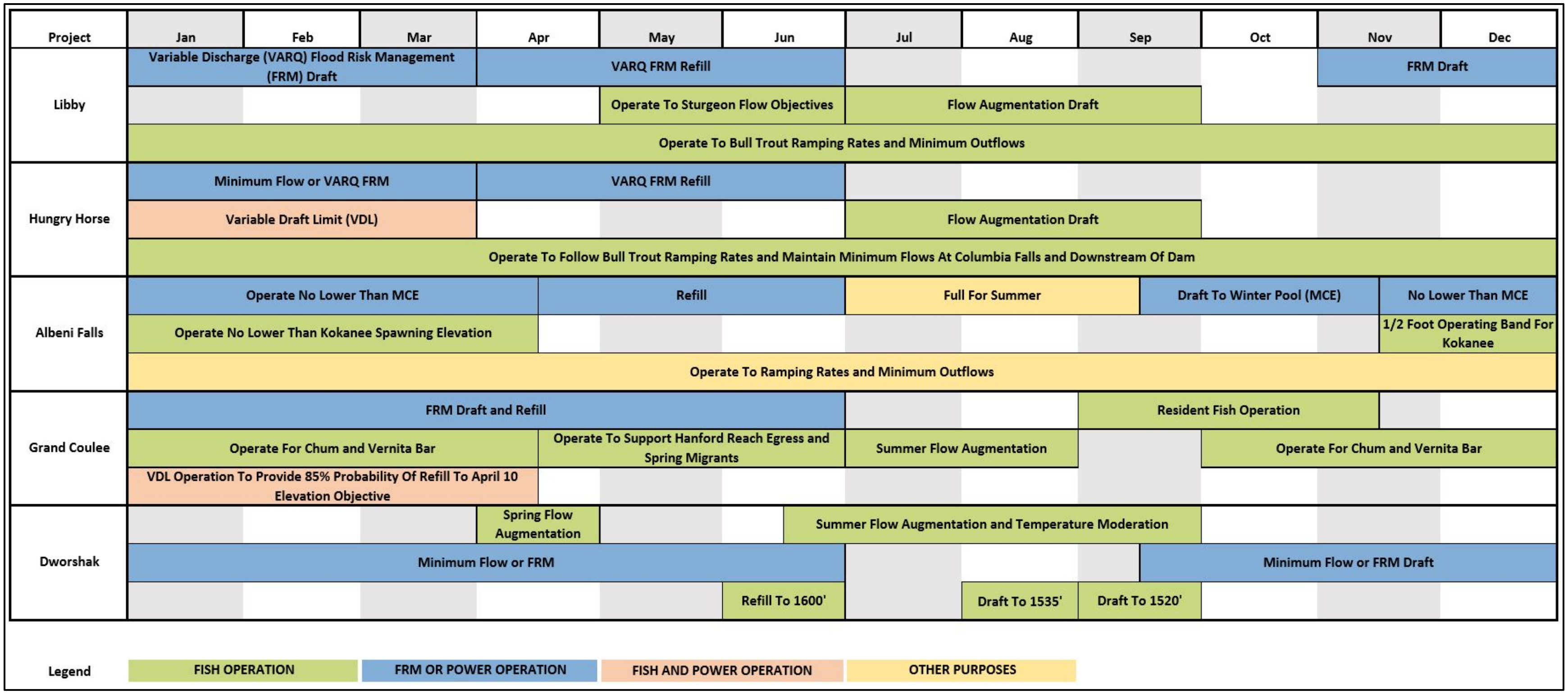



**Figure 3-7. Seasonal Operations at Major Columbia River System Storage Dams**

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

#### *3.2.4.2 Effects (Summary)*

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

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

[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*).

**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<br>April 10 elevation between 2,410 and 2,325 feet in the middle 50% of years<br>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**)<br>April 10 elevation between 2,407 and 2,332 feet in the middle 50% of years (**narrower band than NAA**)<br>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**)<br>April 10 elevation between 2,392 and 2,333 feet in the middle 50% of years (**narrower band than NAA**)<br>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**)<br>April 10 elevation between 2,392 and 2,333 feet in the middle 50% of years (**narrower band than NAA**)<br>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**)<br>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**)<br>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<br>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**)<br>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**)<br>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**)<br>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**)<br>Median monthly outflow for Jul, Aug, and Sep is 14, 10, and 8 kcfs, respectively (**higher than NAA for Jul**) |

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

| 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<br>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)<br>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)<br>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)<br>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**)<br>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<br>April 10 elevation between 1,271 and 1,245 feet in the middle 50% of years<br>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**)<br>April 10 elevation between 1,268 and 1,244 feet in the middle 50% of years (**lower than NAA**)<br>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**)<br>April 10 elevation between 1,270 and 1,244 feet in the middle 50% of years (**lower than NAA**)<br>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)<br>April 10 elevation between 1,271 and 1,245 feet in the middle 50% of years (same as NAA)<br>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**)<br>April 10 elevation between 1,270 and 1,244 feet in the middle 50% of years (**lower than NAA**)<br>Median elevation for Jul, Aug, and Sep: 1,286, 1,279, and 1,279 feet, respectively (**lower than NAA**) |

| 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<br>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**)<br>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**)<br>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)<br>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**)<br>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<br>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<br>(same as NAA)<br>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<br>(**lower than NAA in Jan to Apr**; same as NAA in May)<br>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<br>(same as NAA)<br>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<br>(same as NAA)<br>Median elevation for Jun, Jul, Aug, and Sep: 1,596, 1,589, 1,555, and 1,522 feet, respectively (same as NAA) |

| 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<br>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)<br>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)**<br>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)<br>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)<br>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<br>1-foot MOP range (733.0–734.0 feet) from Apr 3 to Aug 31<br>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<br>1-foot MOP range (633.0–634.0 feet) from Apr 3 to Aug 31<br>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**) |

| Indicator | NAA | MO1 | MO2 | MO3 | MO4 |
|---|---|---|---|---|---|
| Lower Monumental Dam Reservoir[3/] | Normal operating range 537.0–540.0 feet<br>1-foot MOP range (537.0–538.0 feet) from Apr 3 to Aug 31<br>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<br>1-foot MOP range (437.0–438.0 feet) from Apr 3 to Aug 31<br>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**) |

| 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 from Jan 1 to Mar 14, 262.5–265.0 feet from Mar 15 to Apr 9<br>1.5-foot MIP range (262.5–264.0 feet) from Apr 10 to Sep 30<br>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**)<br>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**) |

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

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 expected elevations from October through May would actually be 1 to 3 feet higher than shown in this table for those two MOs.

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 model, so appears as 2,062.3 feet NGVD29 in this table.

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

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

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

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

**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) |

| 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 | 40% Total Outflow |
| | | 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) |

| 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 | 33 kcfs (Waiver Gas Cap) |
| | | 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) |

| 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 |

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

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

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

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

#### *3.2.4.3 No Action Alternative*

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

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

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

There would not be much variability in water levels in October and November. In December, the range of the reservoir water level begins to spread, as the end of December FRM elevation for Libby Dam is based on a seasonal water supply forecast that is issued at the beginning of December. The range of possible reservoir elevations widens further in the subsequent winter months, lasting into the early spring. The drawdown of the reservoir level that occurs in the winter and early spring months is guided by variable discharge storage regulation procedure (VarQ) FRM requirements, and also by minimum outflow requirements. The reservoir usually begins refilling by April or May and reaches its peak elevation in July. Libby Dam releases water and drafts over the summer to help meet flow objectives in the lower Columbia River for juvenile anadromous fish migration. The elevation objective at the end of September is either elevation 2,449 feet NGVD29 or elevation 2,439 feet NGVD29. The elevation objective of 2,439 feet NGVD29 applies in the driest 20 percent of years,[8] based on the May issued April to August water supply forecast at The Dalles. In all other years, the elevation objective of 2,449 feet NGVD29 applies.

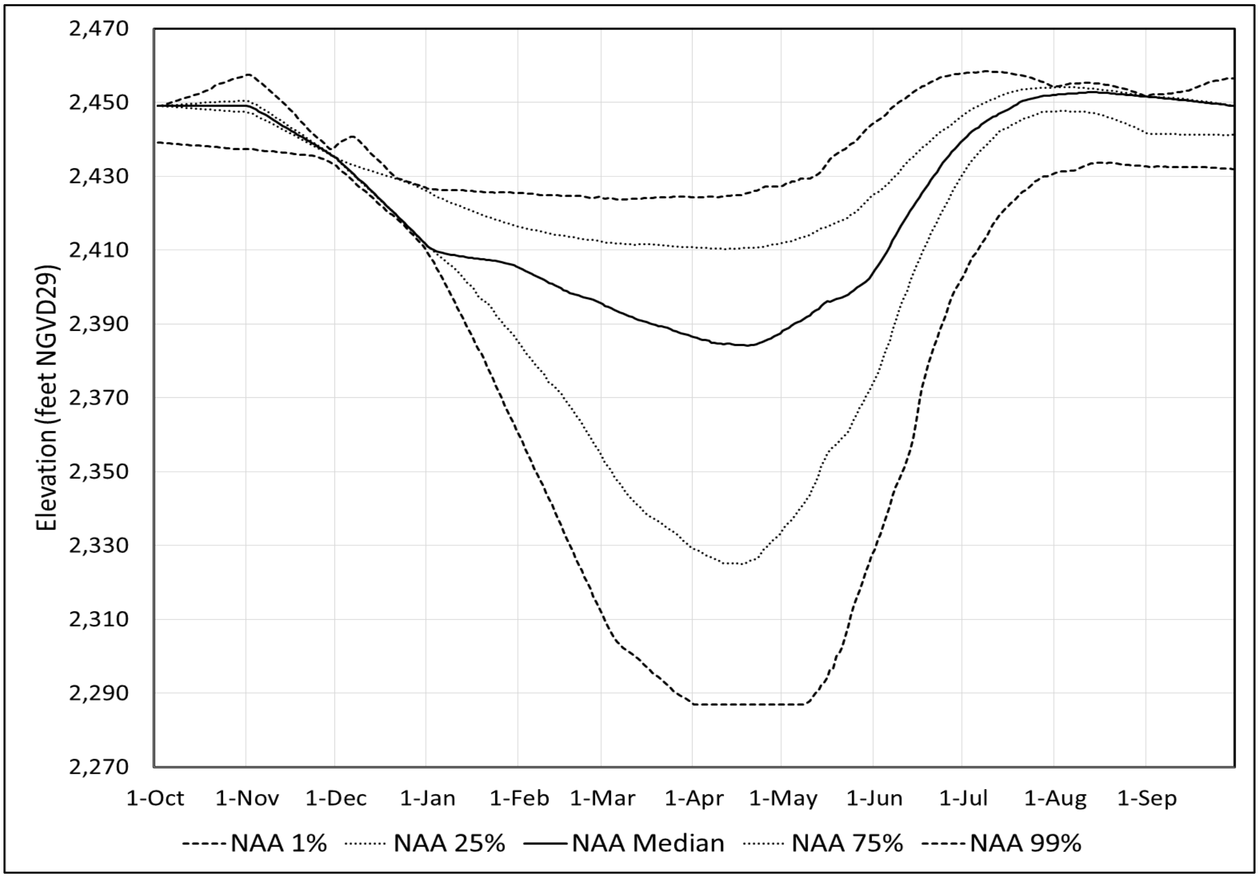



**Figure 3-8. Lake Koocanusa Summary Hydrograph for No Action Alternative**

### Libby Dam Outflow

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

Outflow in October is typically less than 5 kcfs. It increases in November and usually increases again in December, though not always. From January through March, the range of outflow from Libby Dam can be quite wide, as seen in the difference between the 25th percentile and 75th percentile lines on the Figure 3-9 summary hydrograph. By about mid-May, there is usually a pronounced increase in Libby Dam outflow for several weeks to provide flows for Kootenai River white sturgeon. Following the pronounced increase, the outflow gradually decreases over the remaining months of the water year. In addition to outflows for Kootenai River white 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).

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

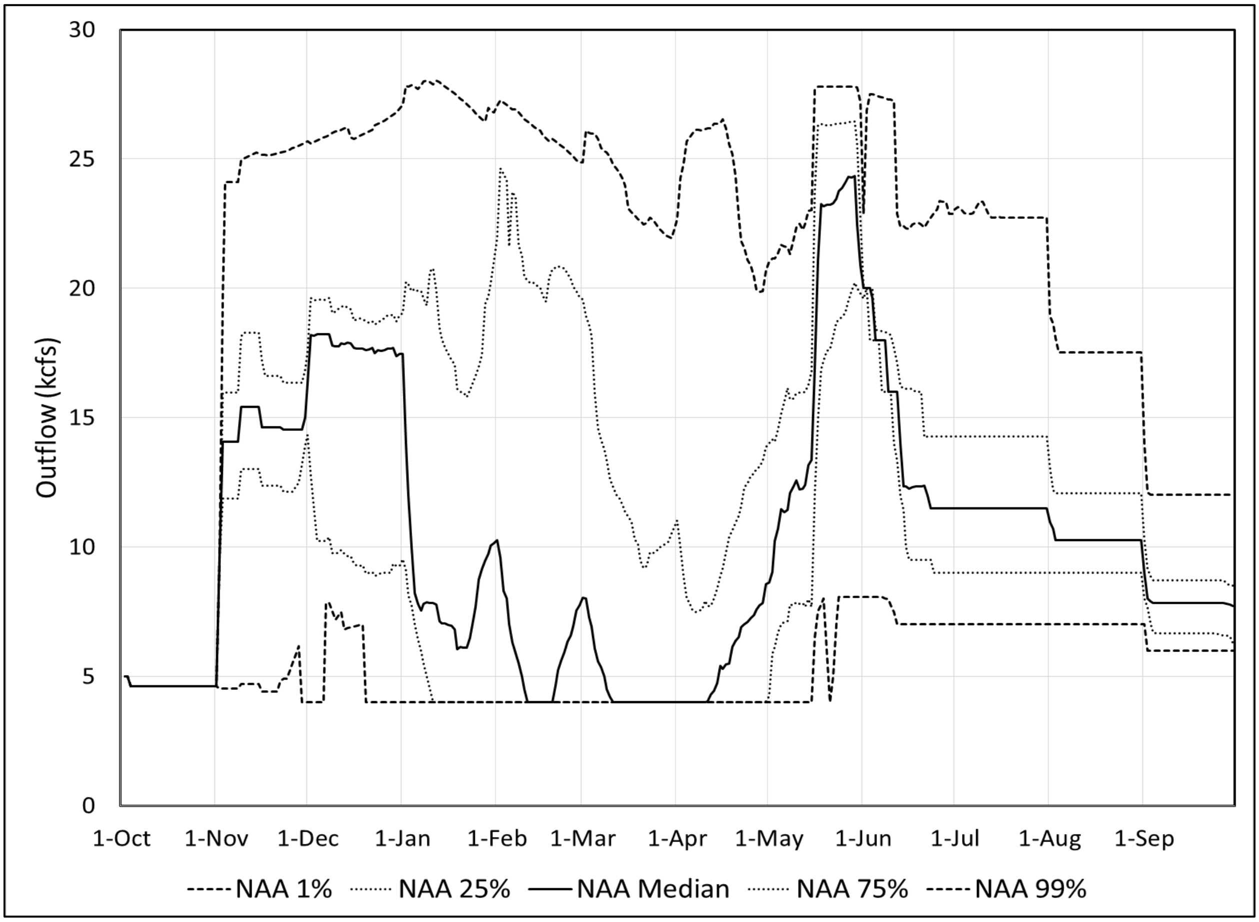



**Figure 3-9. Libby Dam Outflow Summary Hydrograph for No Action Alternative**

### Bonners Ferry Flow

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

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

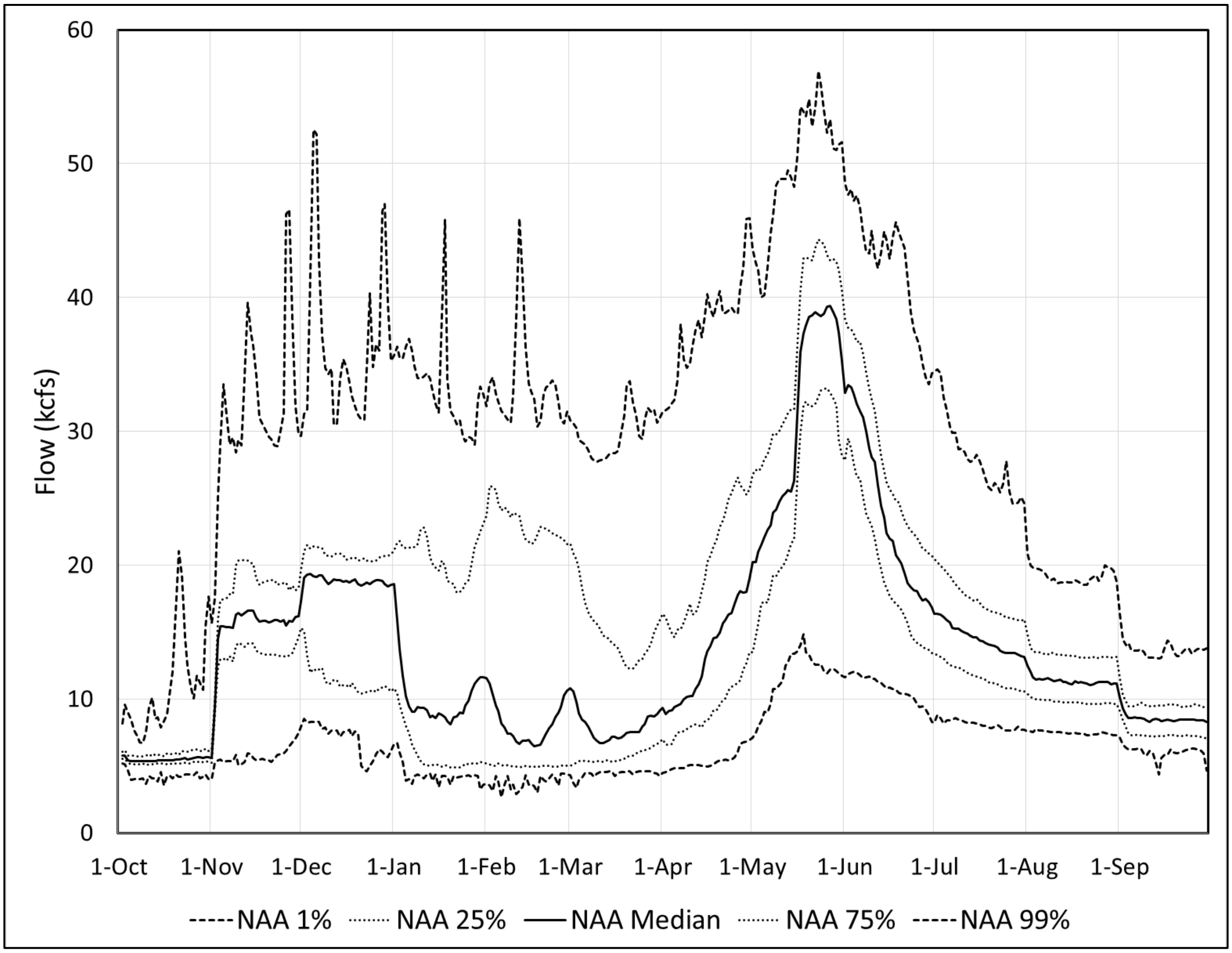



**Figure 3-10. Bonners Ferry Flow Summary Hydrograph for No Action Alternative**

**Hungry Horse Reservoir Elevation**

A summary hydrograph showing Hungry Horse Reservoir elevations for the No Action Alternative is shown in Figure 3-11.

There is not much variability in water levels at the start of the water year. Over the next several months, the range of the reservoir water level begins to spread, as Hungry Horse is operated to meet minimum flows and continues to draft depending on inflow conditions. The range of possible reservoir elevations widens further in the subsequent winter months, lasting into the early spring. The drawdown of the reservoir level that occurs in the winter and early spring months is guided by VarQ FRM requirements. In real time, however, the reservoir may also be deeper than the VarQ FRM elevation to operate for power, so long as there is a 75 percent chance of being at the elevation objective on April 10 (this is referred to as a variable draft limit). The reservoir is also deeper than the VarQ FRM elevation when needed to meet minimum flows for bull trout on the South Fork Flathead River and on the mainstem Flathead River at Columbia Falls. The reservoir typically experiences the deepest draft point in late April or early May to satisfy VarQ FRM requirements. The reservoir usually begins refilling in early

May and reaches its peak elevation in late June to early July. Hungry Horse Dam releases water and drafts over the summer to help meet flow objectives in the lower Columbia River for juvenile anadromous fish migration. The elevation objective at the end of September is either elevation 3,550 feet NGVD29 or elevation 3,540 feet NGVD29. The elevation objective of 3,540 feet NGVD29 applies in the driest 20 percent of years[9], based on the May issued April to August water supply forecast at The Dalles. In all other years, the elevation objective of 3,550 feet NGVD29 applies. In dry years, the need to satisfy local minimum flow requirements can cause the reservoir to be lower than its end of September elevation objective.

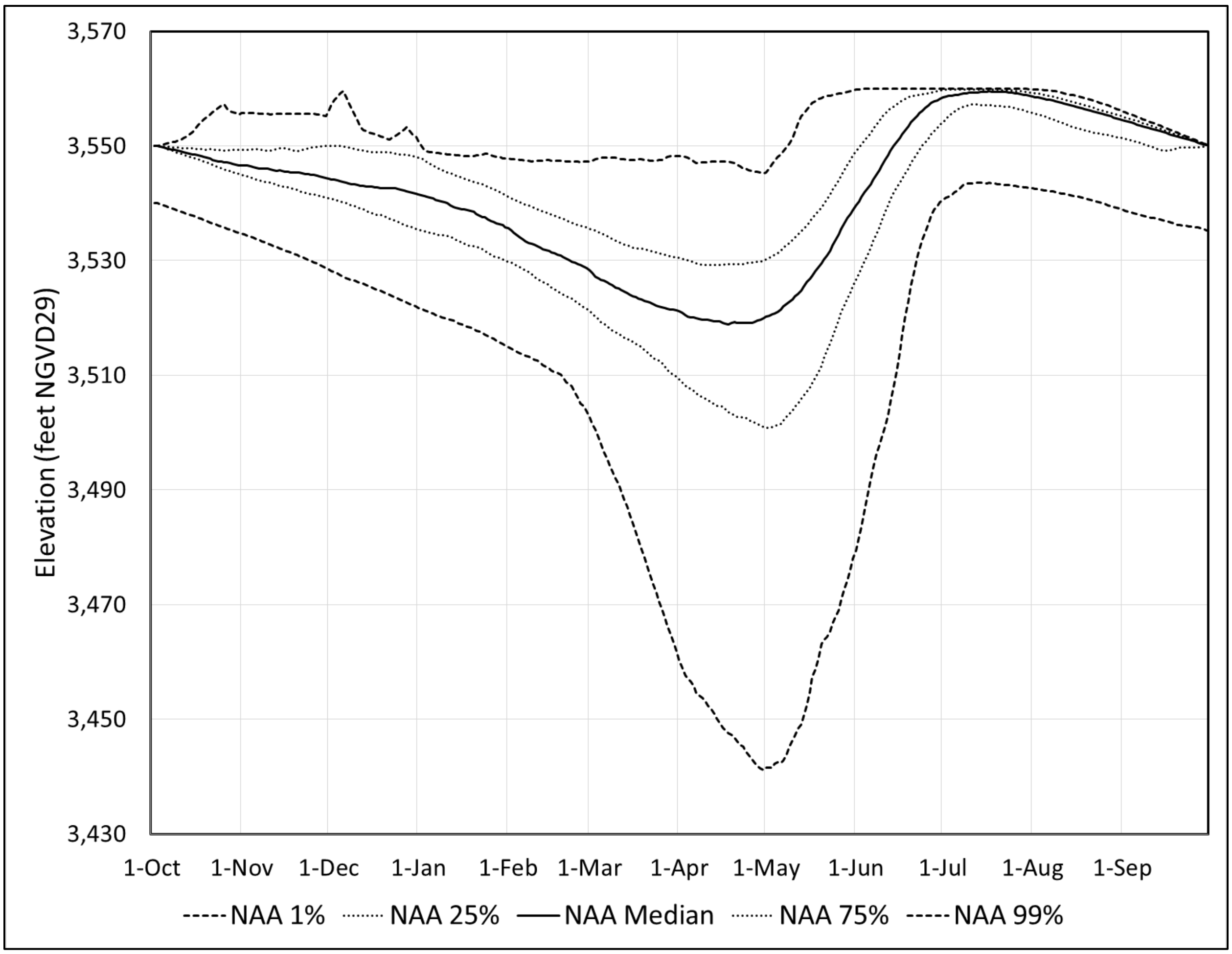



**Figure 3-11. Hungry Horse Reservoir Summary Hydrograph for No Action Alternative**

**Hungry Horse Dam Outflow**

A summary hydrograph showing outflow from Hungry Horse Dam for the No Action Alternative 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.

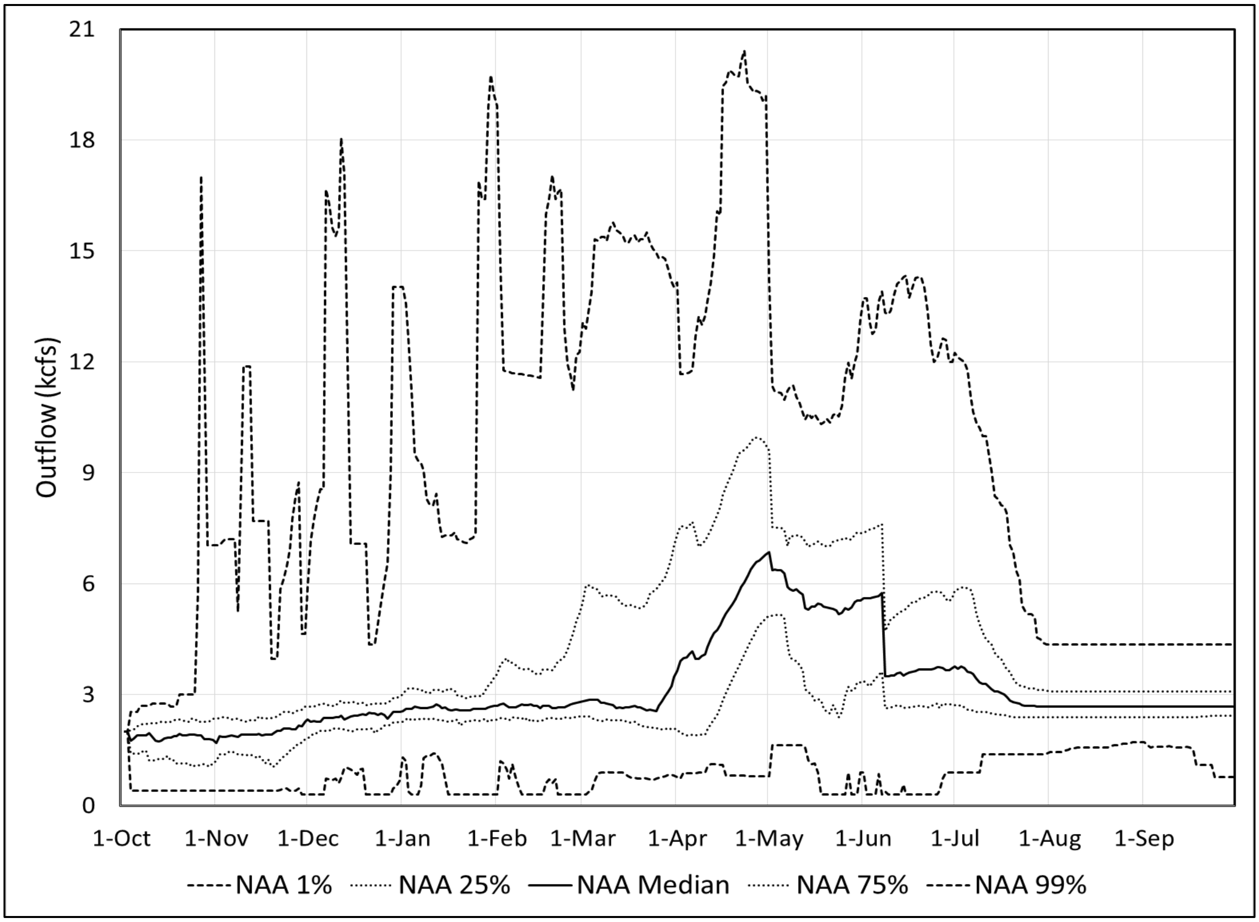



**Figure 3-12. Hungry Horse Dam Outflow Summary Hydrograph for No Action Alternative**

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

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

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

**Columbia Falls Flow**

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

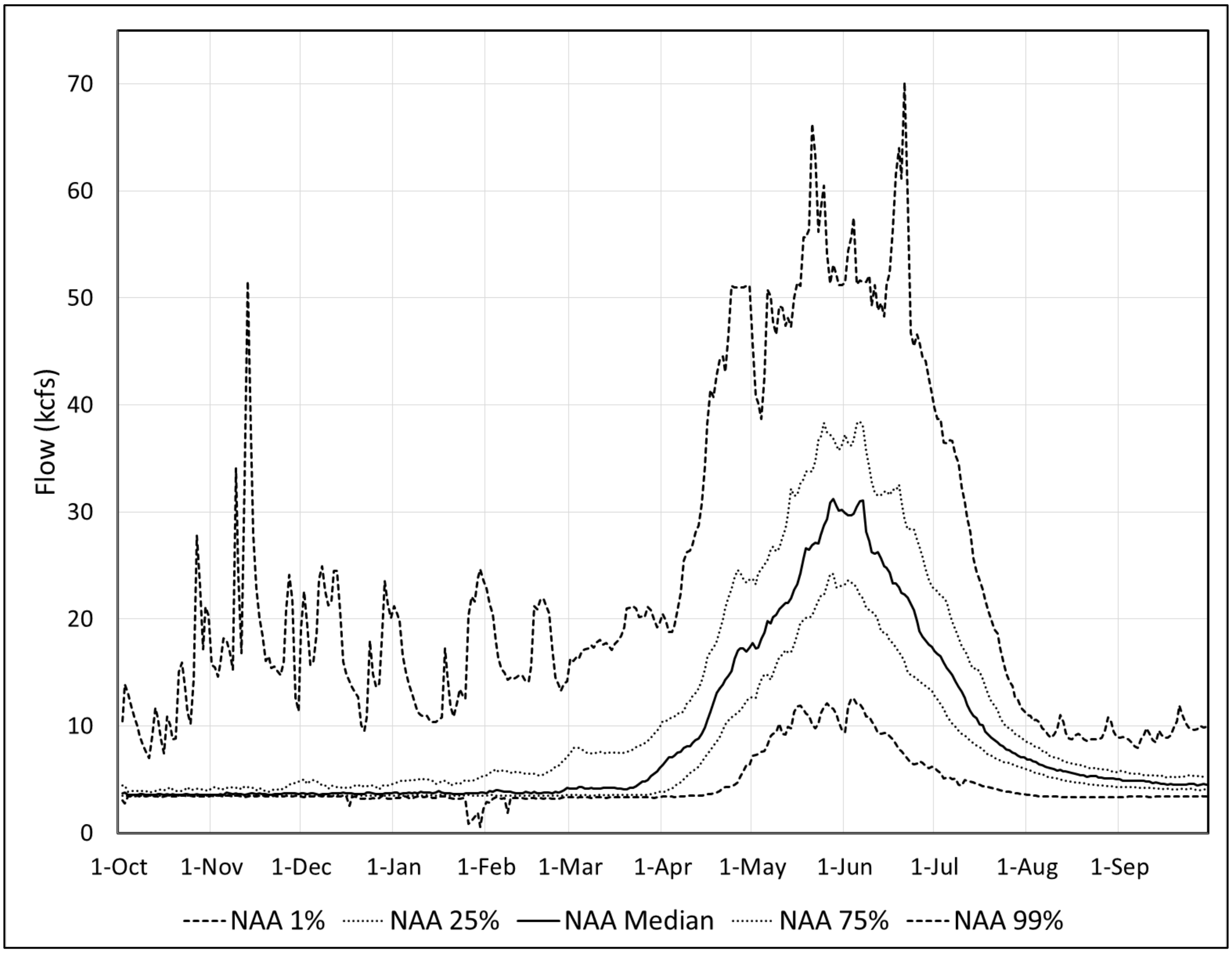



**Figure 3-13. Columbia Falls Flow Summary Hydrograph for No Action Alternative**

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

**Lake Pend Oreille Elevation**

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

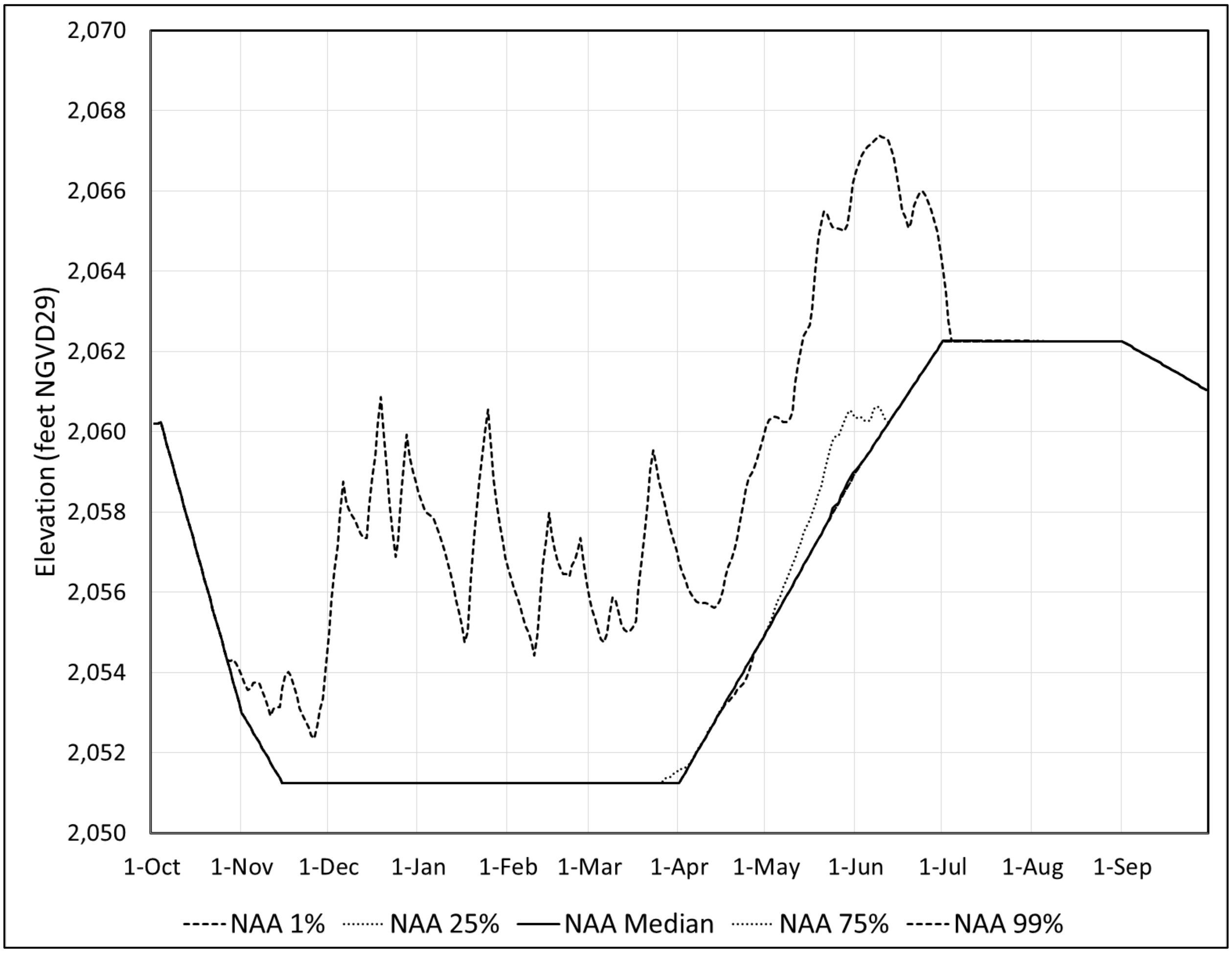



**Figure 3-14. Lake Pend Oreille Summary Hydrograph for No Action Alternative**

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

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

### REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

#### Lake Roosevelt (Grand Coulee Dam Reservoir) Elevation

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

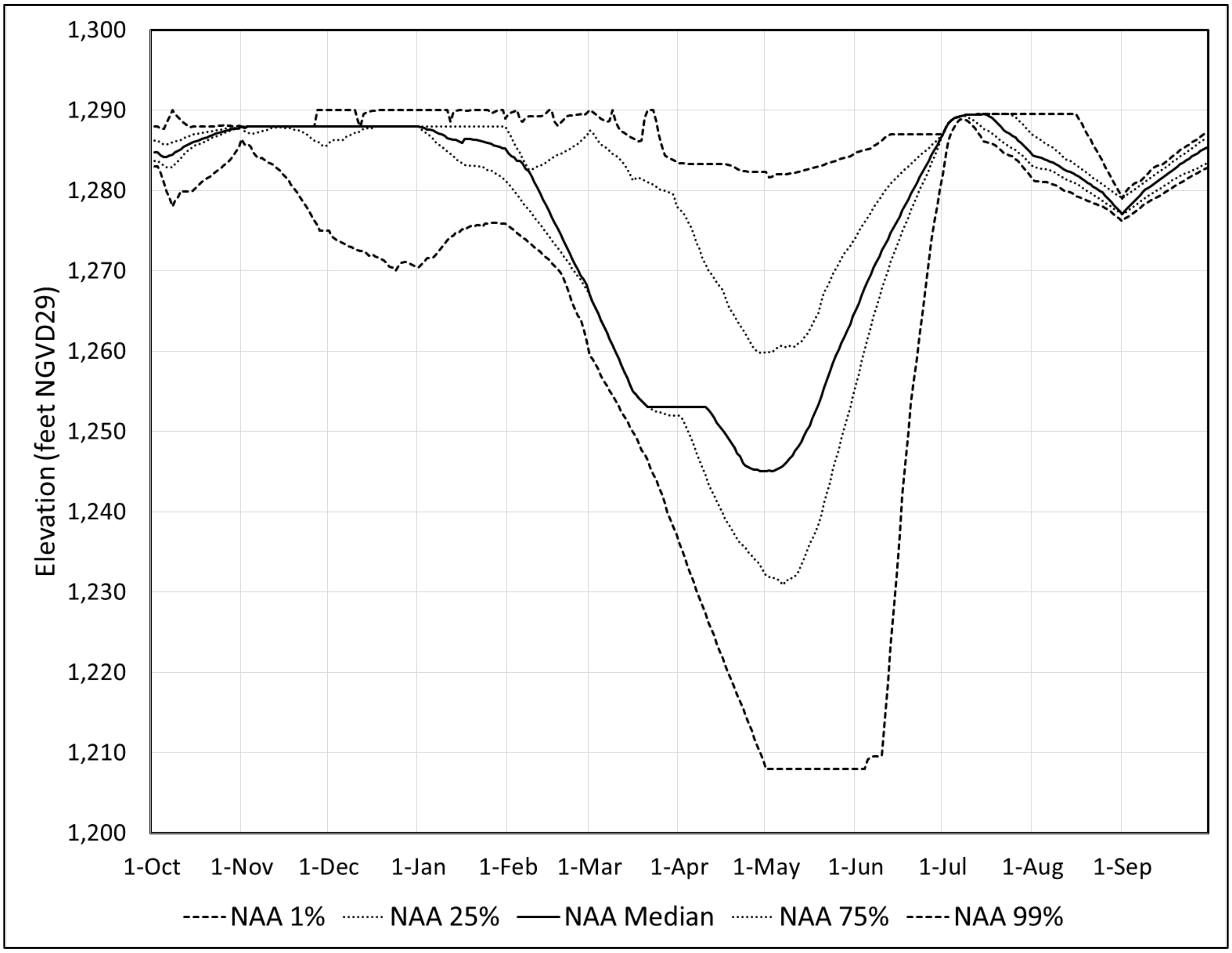



**Figure 3-15. Lake Roosevelt Summary Hydrograph for No Action Alternative**

There is little variability in water levels in the fall, as the Grand Coulee Project is operated to fill from the end of August elevation objective for flow augmentation to 1,283 feet NGDV29 by the end of September for resident fish purposes. The project continues to fill through October to as high as 1,288 feet NGVD29 in preparation for winter power operations and to support chum salmon spawning and incubation below Bonneville Dam. Over the winter months the range of reservoir water level begins to spread, and this generally continues through about mid-spring. Different objectives determine reservoir operations during this period: meeting system FRM requirements, generating power, and providing ecosystem flows (managing flows for chum salmon below Bonneville Dam, and for fall Chinook salmon at Vernita Bar). Grand Coulee Dam operates for multiple purposes throughout the year, including FRM, power, and operations for various fish species. The drawdown of the reservoir level that occurs in the winter and early spring months is guided by FRM requirements. The reservoir may also be deeper than the FRM elevation to operate for power, so long as there is an 85 percent chance of being at the spring elevation objective on April 10 to augment spring flows for migrating juvenile salmon and steelhead (this is referred to as a variable draft limit and is based on interpolation between FRM elevations). The time at which the reservoir begins to refill depends on the Columbia River Basin runoff conditions each year, typically beginning in April or May, and reaching at or near full pool in early July. Reservoir levels gradually drop over July and August, as the project is operated to augment flows to assist migrating juvenile anadromous fish in the lower Columbia River.

**Grand Coulee Dam Outflow**

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

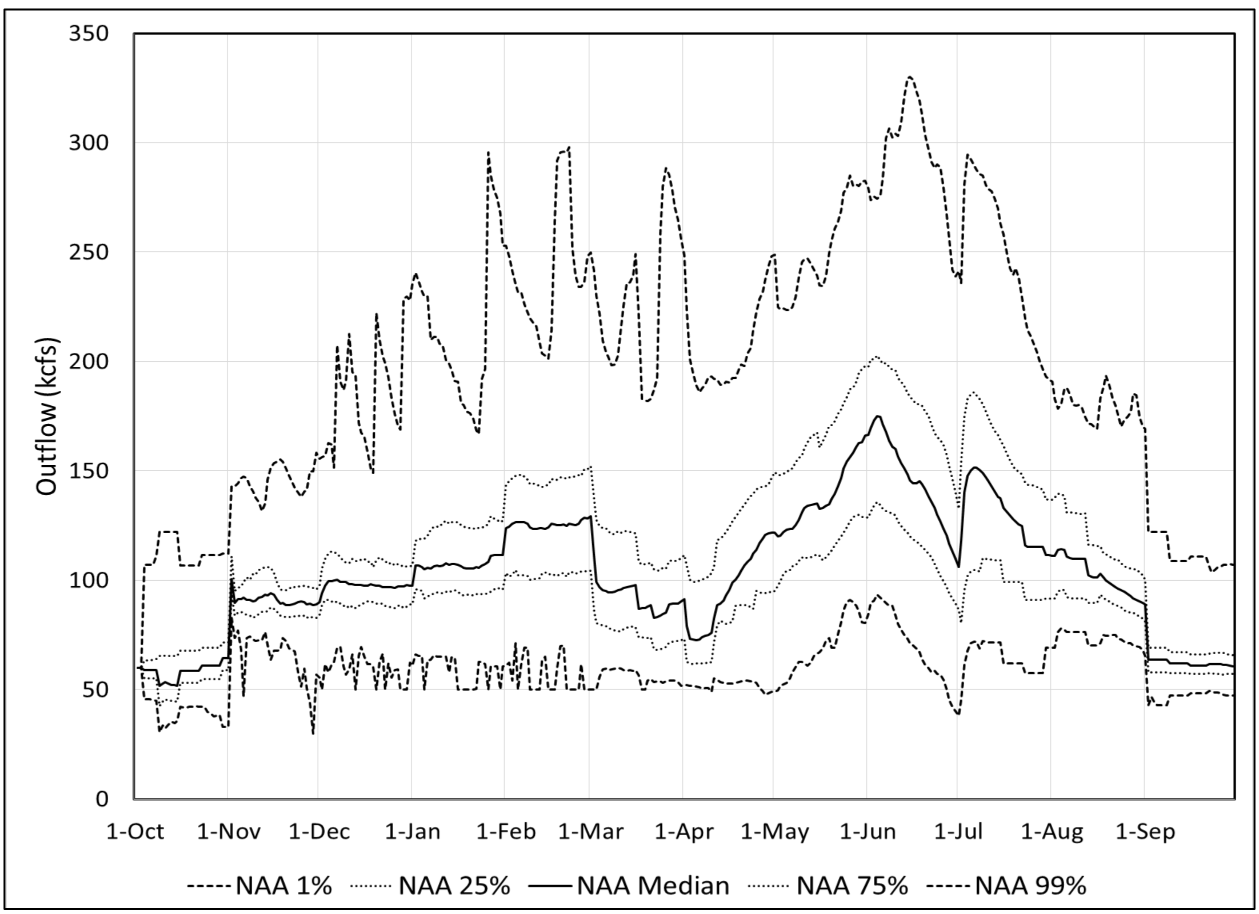



**Figure 3-16. Grand Coulee Dam Outflow Summary Hydrograph for No Action Alternative**

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

### Middle Columbia River below Grand Coulee Dam

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

**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 |

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

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Dworshak Dam

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

The water year generally begins with a reservoir elevation of about 1,520 feet NGVD29. Although there is a wide spread between the 99 percent chance and 1 percent chance exceedance lines for much of the year, the typical seasonal pattern is best understood from viewing the span between the 75 percent chance and 25 percent chance exceedance lines. From October through January, the water level in the reservoir can increase or decrease. The range of possible reservoir elevations widens further in the subsequent winter months, lasting into the early spring. The reservoir level in the winter and early spring months is guided by FRM requirements, and also by minimum outflows. The reservoir begins refilling in the spring and usually reaches its full pool elevation of 1,600 feet NGVD29 by July 1. The reservoir level is drawn down over the summer months to provide cool water to the Snake River, provide flows for salmon migration, and meet the flows per the agreement between the United States and the Nez Perce Tribe, ending at an elevation of 1,520 feet NGVD29 on September 30. Throughout the entire water year, the reservoir levels behind Dworshak Dam are the result of the operations for multiple purposes, broadly categorized in Figure 3-7. Further information on how Dworshak Dam operations are modeled is provided in the H&H Appendix (Appendix B, Part 3, *HEC-ResSim/WAT Documentation*).

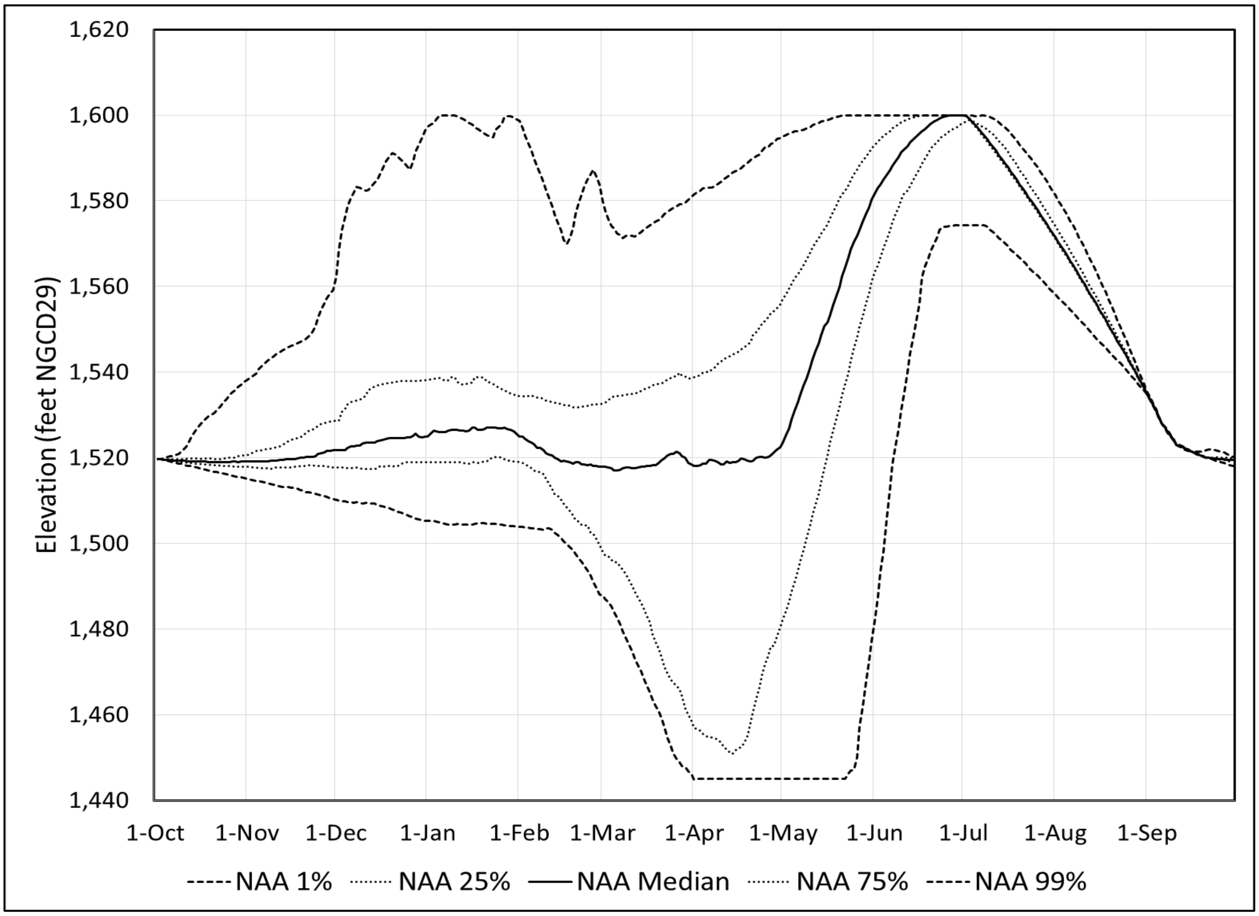



**Figure 3-17. Dworshak Reservoir Summary Hydrograph for No Action Alternative**

**Dworshak Dam Outflow**

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

Flows usually remain low from October through December. The flow in the winter months is generally higher than the fall, as the reservoir is drafted for FRM purposes. Outflow is generally reduced by May so that the reservoir can refill by the beginning of July. In July and August, outflow, typically ranging from 10 to 13 kcfs, is released for flow augmentation and water temperature moderation in the lower Snake River Basin. Releases during the month of September, while the reservoir is between 1,535 and 1,520 feet NGVD29, are made to provide water for salmon migration and to meet flows per the Agreement between the United States and the Nez Perce Tribe. The release is shaped to gradually reduce flows to minimum outflow of 1.6 kcfs over the course of the month.

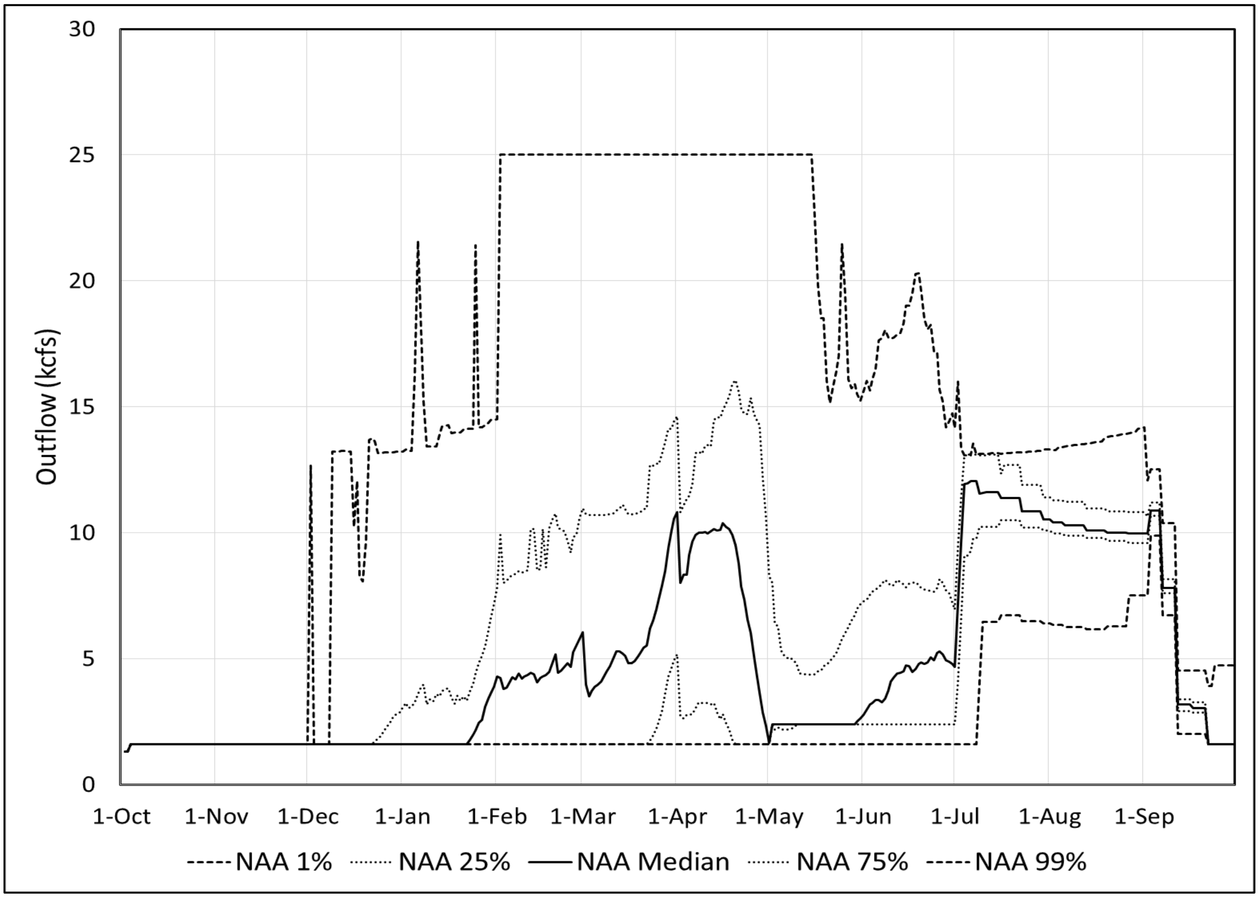



**Figure 3-18. Dworshak Dam Outflow Summary Hydrograph for No Action Alternative**

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

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

**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 |

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

### Lower Columbia River Reservoirs

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

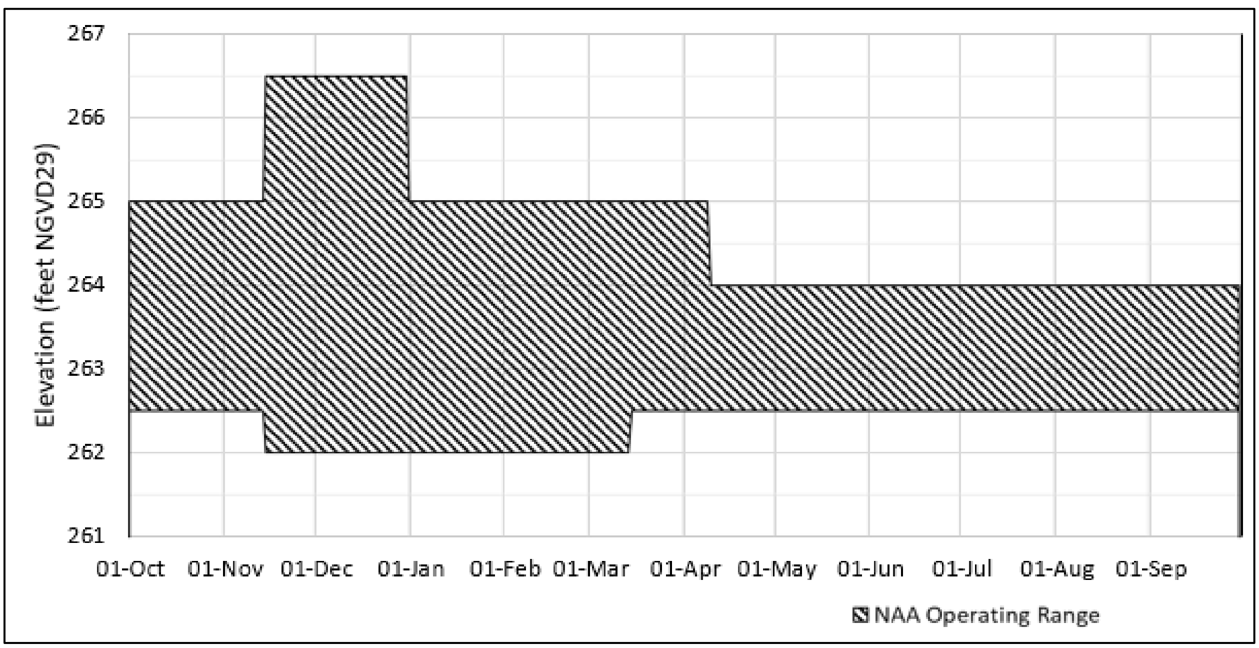



**Figure 3-19. John Day Dam Operating Range for No Action Alternative**

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

### Lower Columbia River Flows

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

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

**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 |

## SUMMARY OF EFFECTS

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

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

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

#### *3.2.4.4 Multiple Objective Alternative 1*

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

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

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

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

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

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

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

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

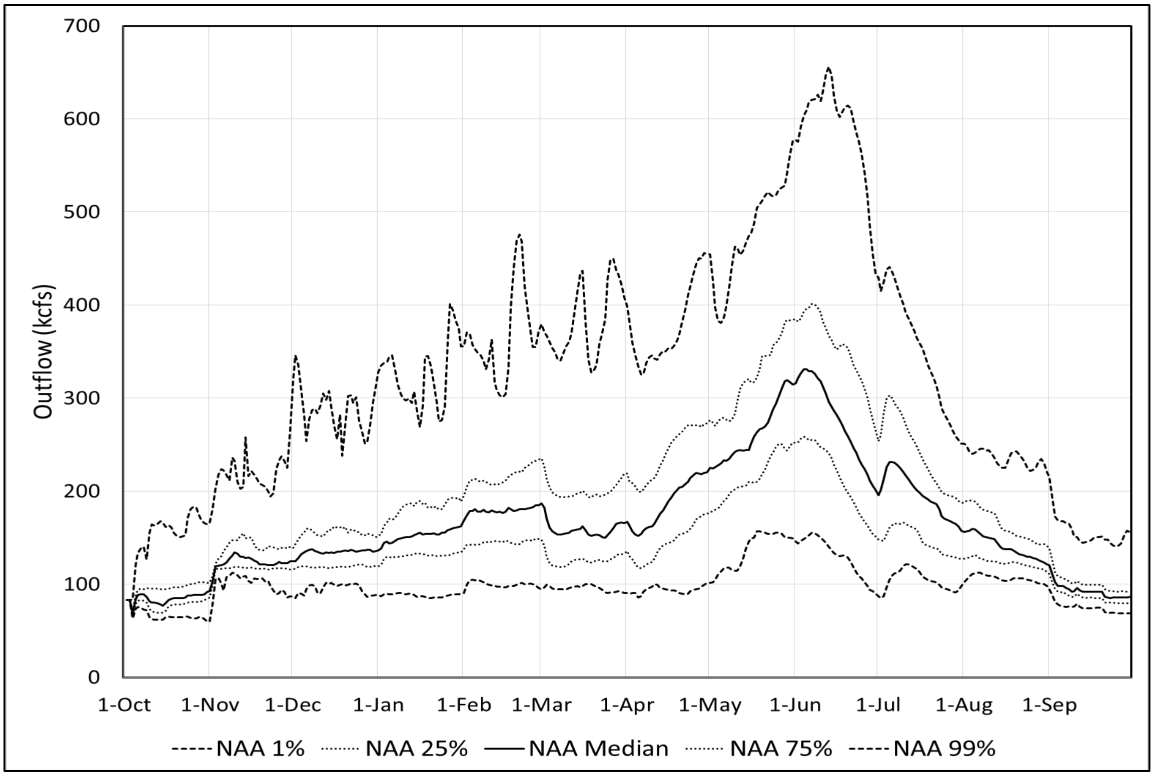



**Figure 3-20. McNary Dam Outflow Summary Hydrograph for No Action Alternative**

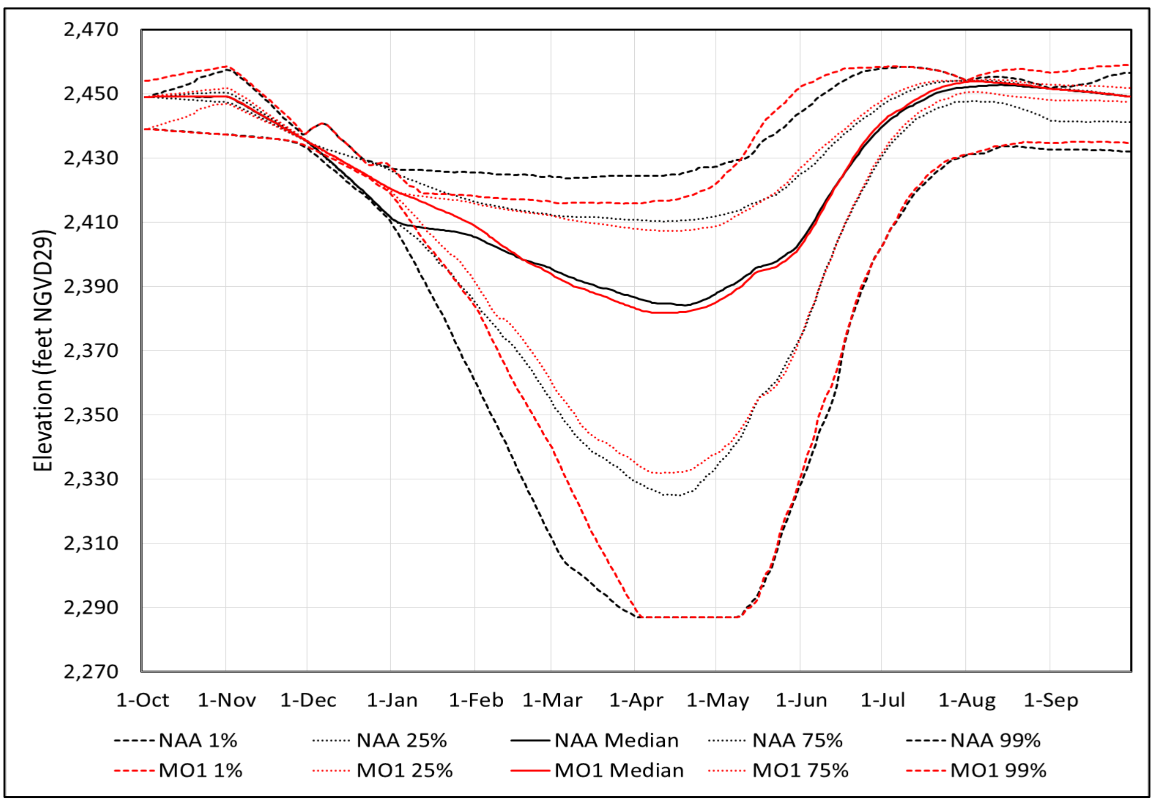



**Figure 3-21. Lake Koocanusa Summary Hydrograph for Multiple Objective Alternative 1**

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

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

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

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

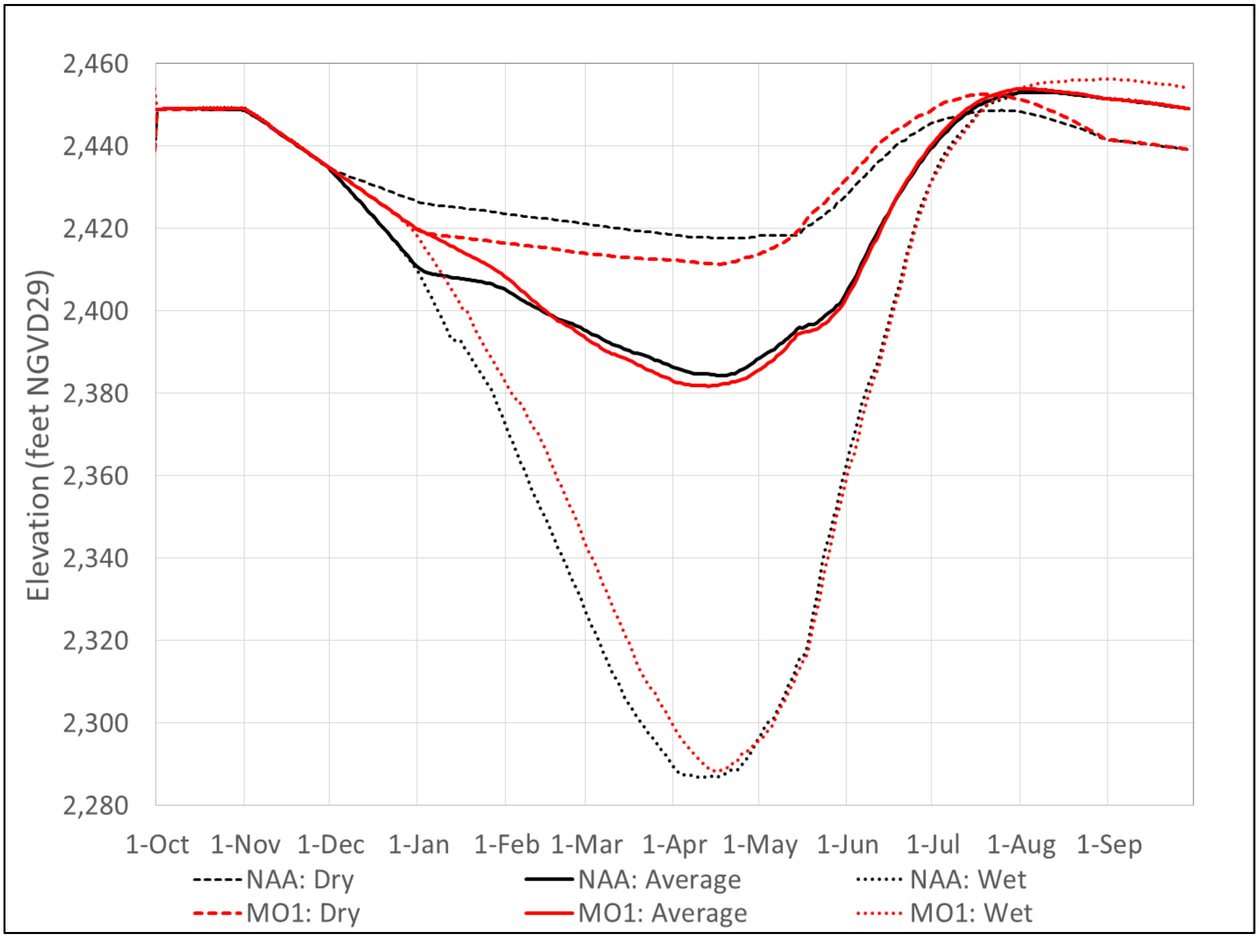



**Figure 3-22. Lake Koocanusa Water Year Type Hydrographs for Multiple Objective Alternative 1**

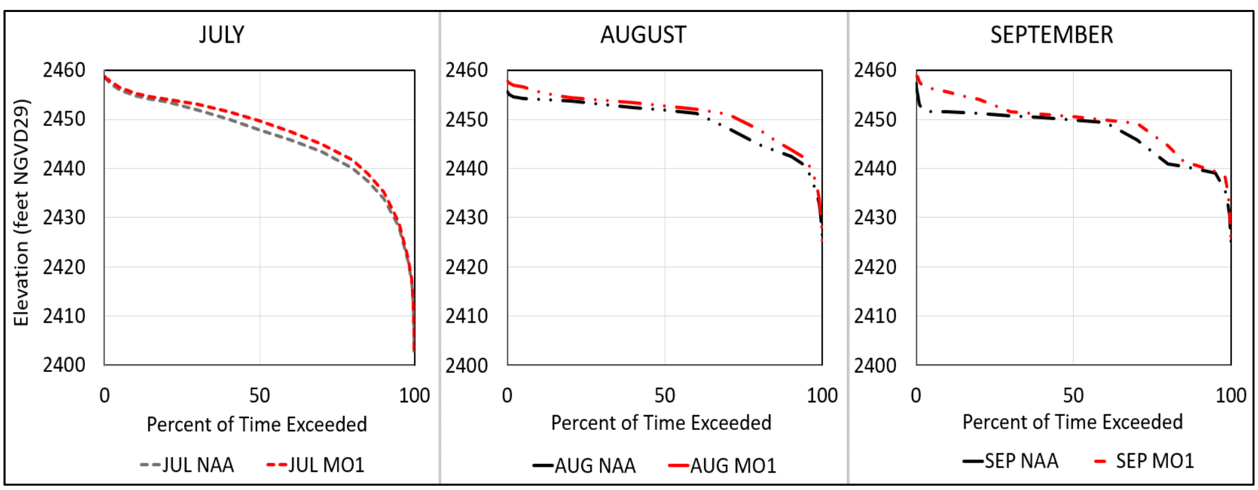



**Figure 3-23. Lake Koocanusa Summer Elevations for Multiple Objective Alternative 1**

### Libby Dam Outflow

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

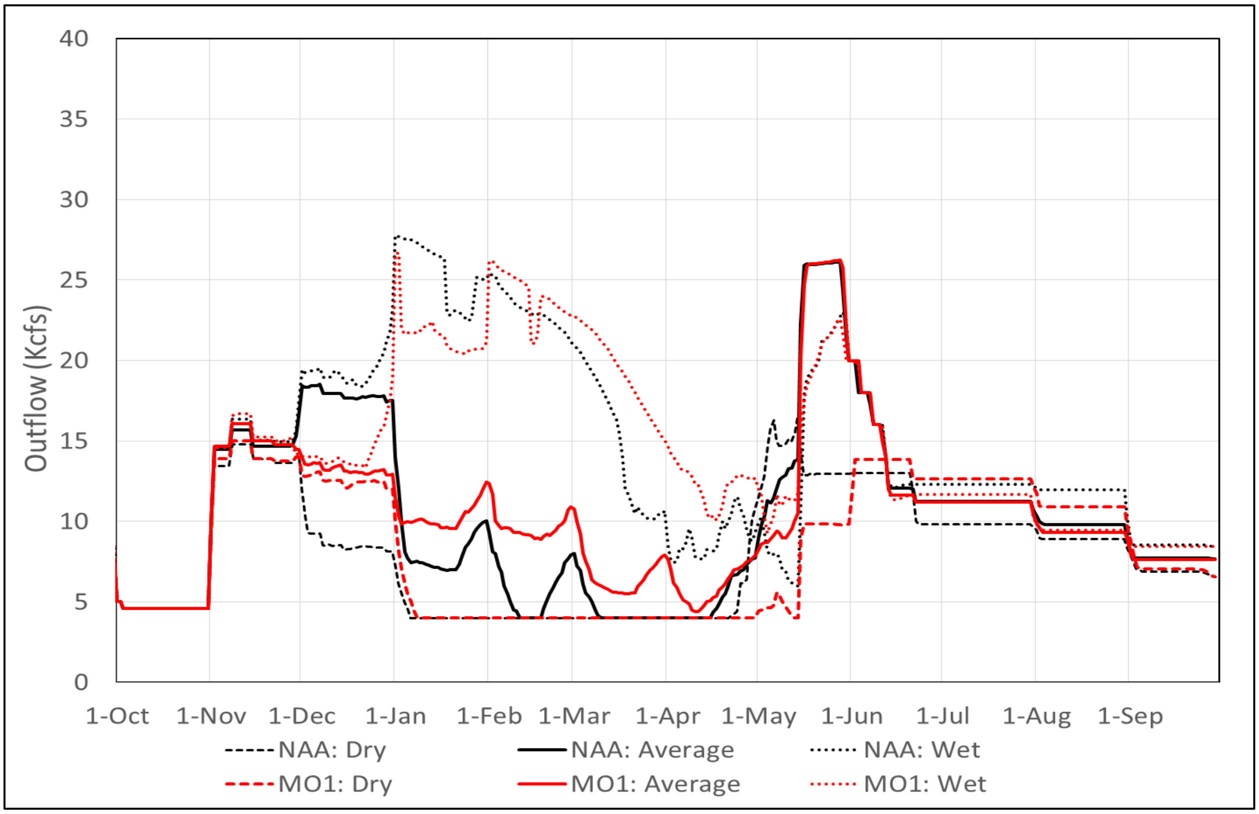



**Figure 3-24. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1**

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

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

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

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

**Table 3-9. Libby Dam Monthly Average Outflow for Multiple Objective Alternative 1 (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% | 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% |

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

### Bonners Ferry Flow

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

**Table 3-10. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 1 (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% | 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% |

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

### Hungry Horse Reservoir Elevation

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

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

The water year would begin with the reservoir levels for MO1 being lower than those for the No Action Alternative. This is because the operations associated with the *Hungry Horse Additional Water Supply* measure would leave the reservoir at a lower elevation on September 30 than under the No Action Alternative, and the condition would carry over to the following water year. It should be noted that when MO1 was modeled, the initial Hungry Horse Reservoir levels at the start of each water year were erroneously set lower than intended. This initialization error had little effect downstream from Hungry Horse Dam. Hungry Horse Dam's modeled releases were up to 1 kcfs lower than they should have been, but by the time flow reaches Flathead Lake, the MO1 results have little error. A subsequent sensitivity analysis revealed that this initialization error primarily affected results in the fall and winter. In the summary hydrograph shown in Figure 3-25, the median and higher elevations should have water levels 1 to 3 feet higher than shown from October through May. Below the median, the results should be 5 to 10 feet higher from October through February.

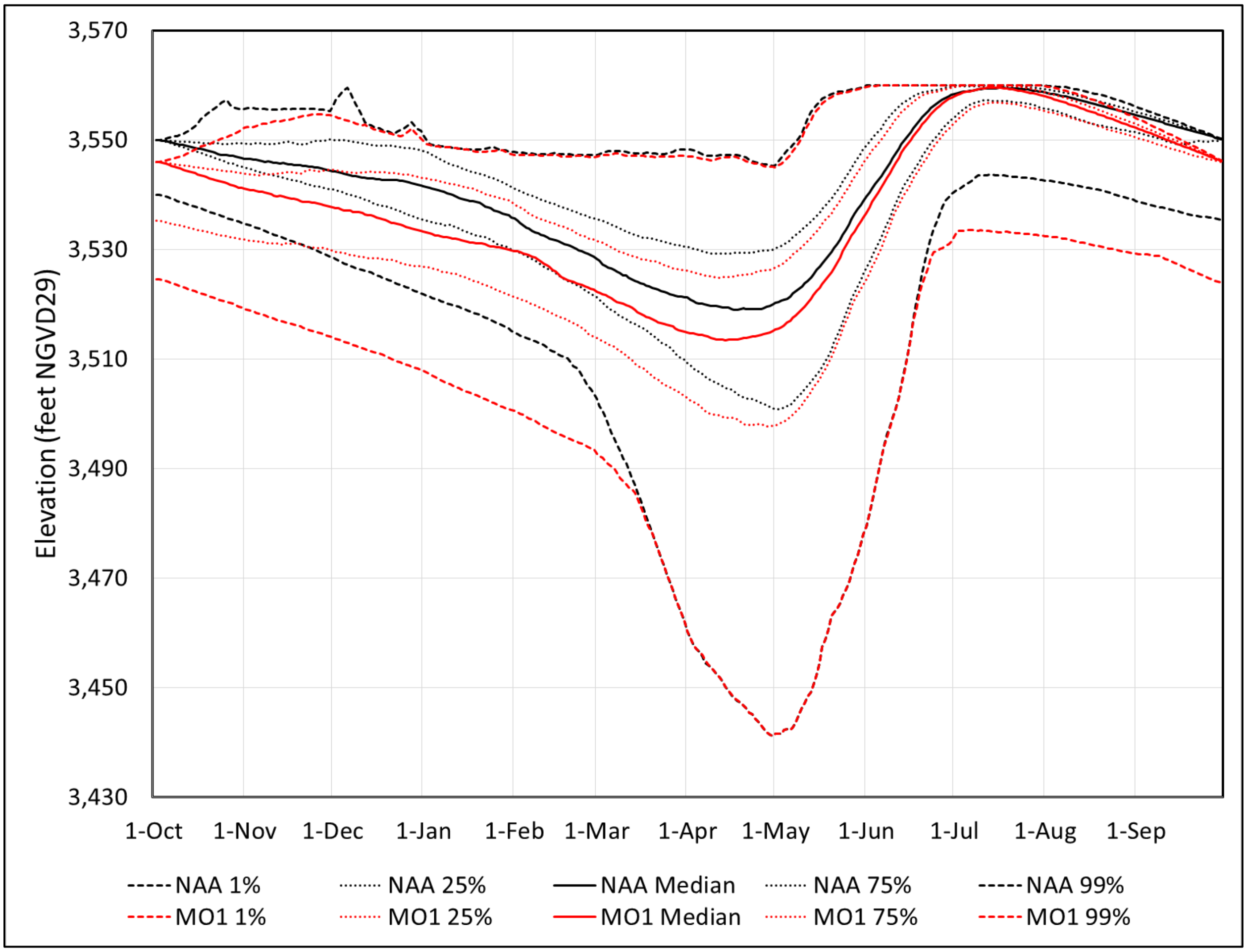



**Figure 3-25. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 1**

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

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

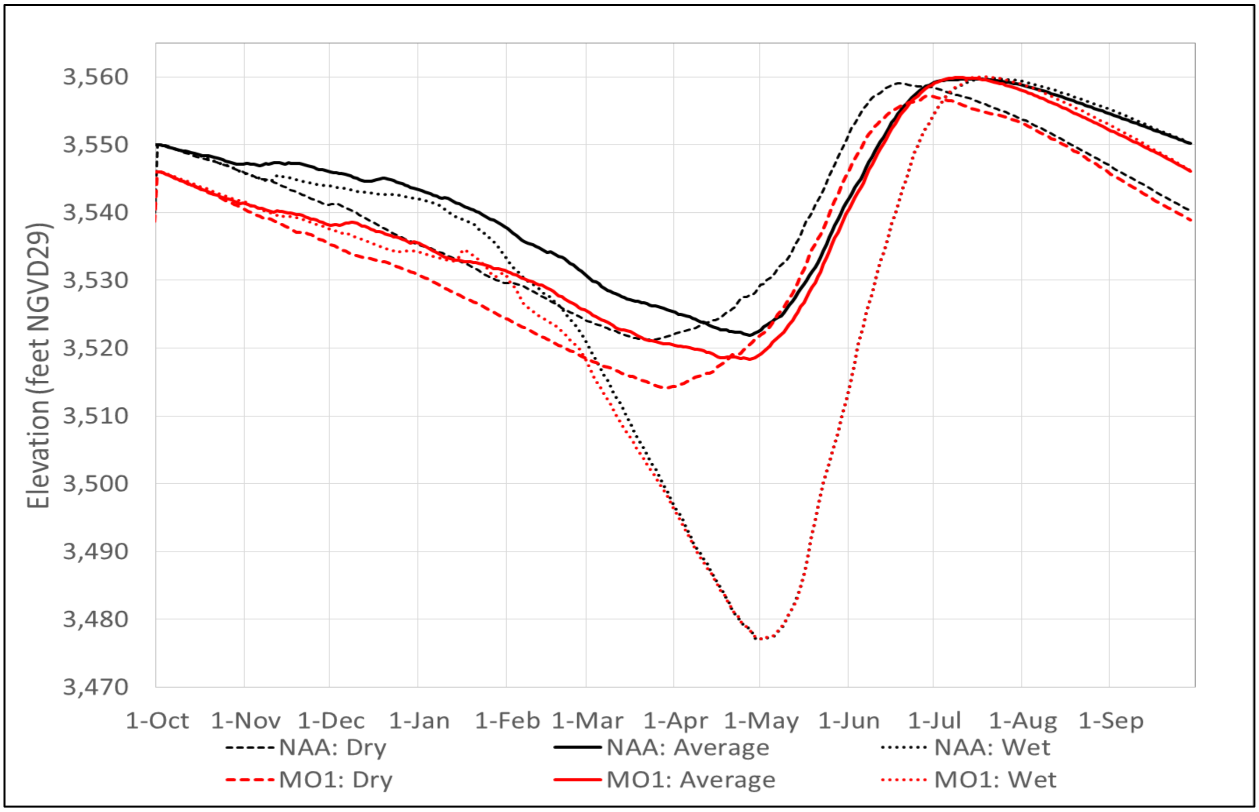



**Figure 3-26. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 1**

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

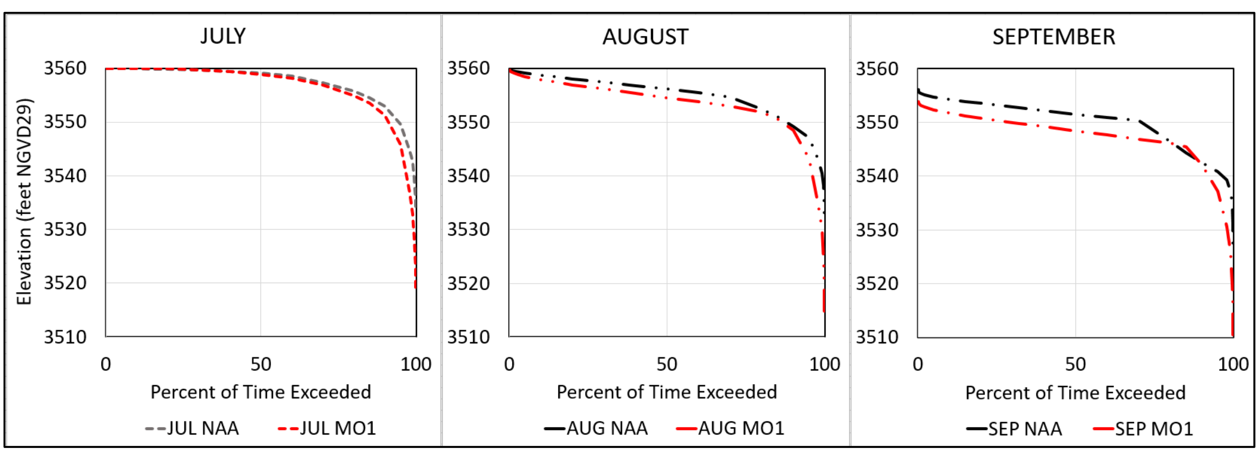



**Figure 3-27. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 1**

**Hungry Horse Dam Outflow**

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

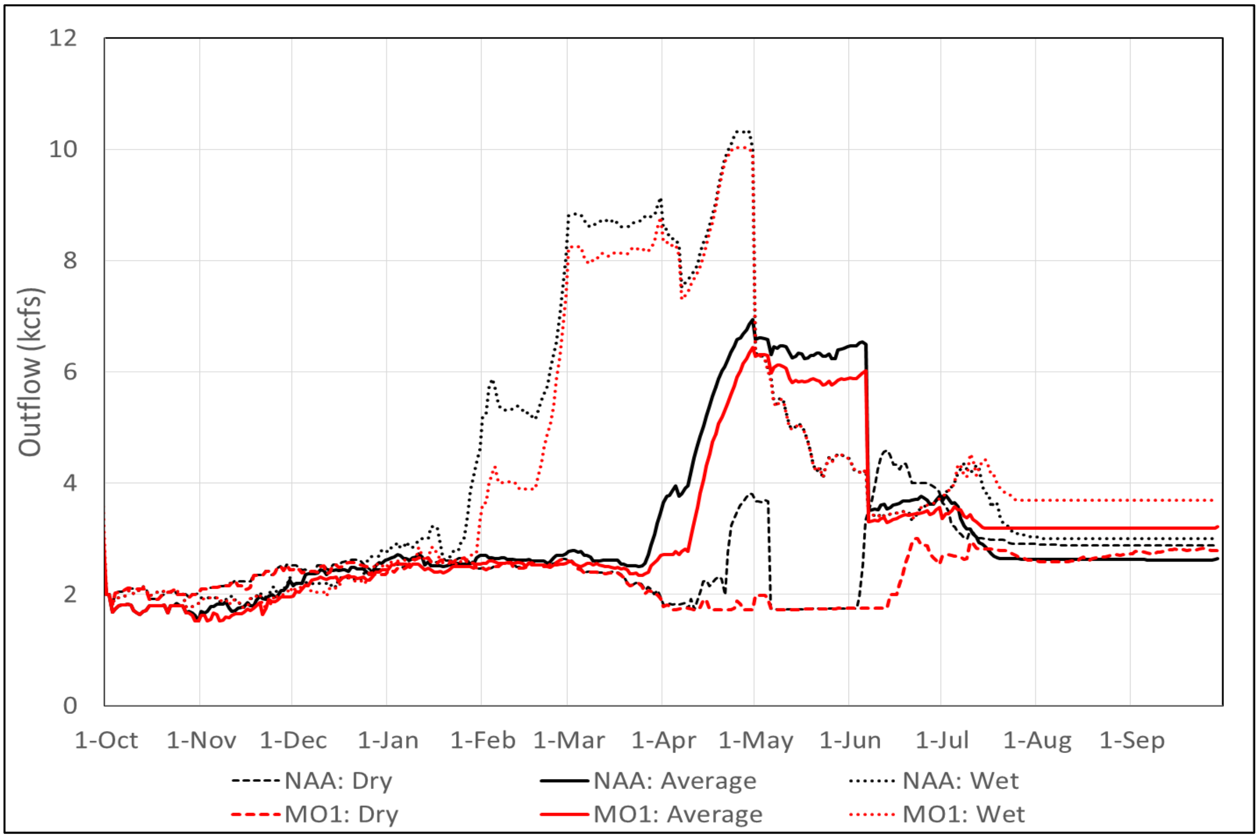



**Figure 3-28. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1**

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

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

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

**Table 3-11. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 1 (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 | 1.8 | 1.9 | 2.0 |
| 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% |

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

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

### Columbia Falls Flow

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

**Table 3-12. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 1 (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% | 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% |

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

### Lake Pend Oreille Elevation

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

### Albeni Falls Outflow

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

**Table 3-13. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 1 (as 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 |
| NAA (kcfs) | 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 |
| NAA (kcfs) | 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 |
| Change (kcfs) | 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 |
| Change (kcfs) | 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% |
| Percent Change | Columbia Falls, MT | 0% | -1% | 0% | -2% | -2% | -9% | -6% | -1% | -1% | 2% | 7% | 11% |
| Percent Change | Albeni Falls | 0% | 0% | 0% | -1% | -2% | -1% | -3% | -1% | -1% | -1% | 0% | -1% |

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

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

### Columbia River flow upstream of Grand Coulee Dam

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

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

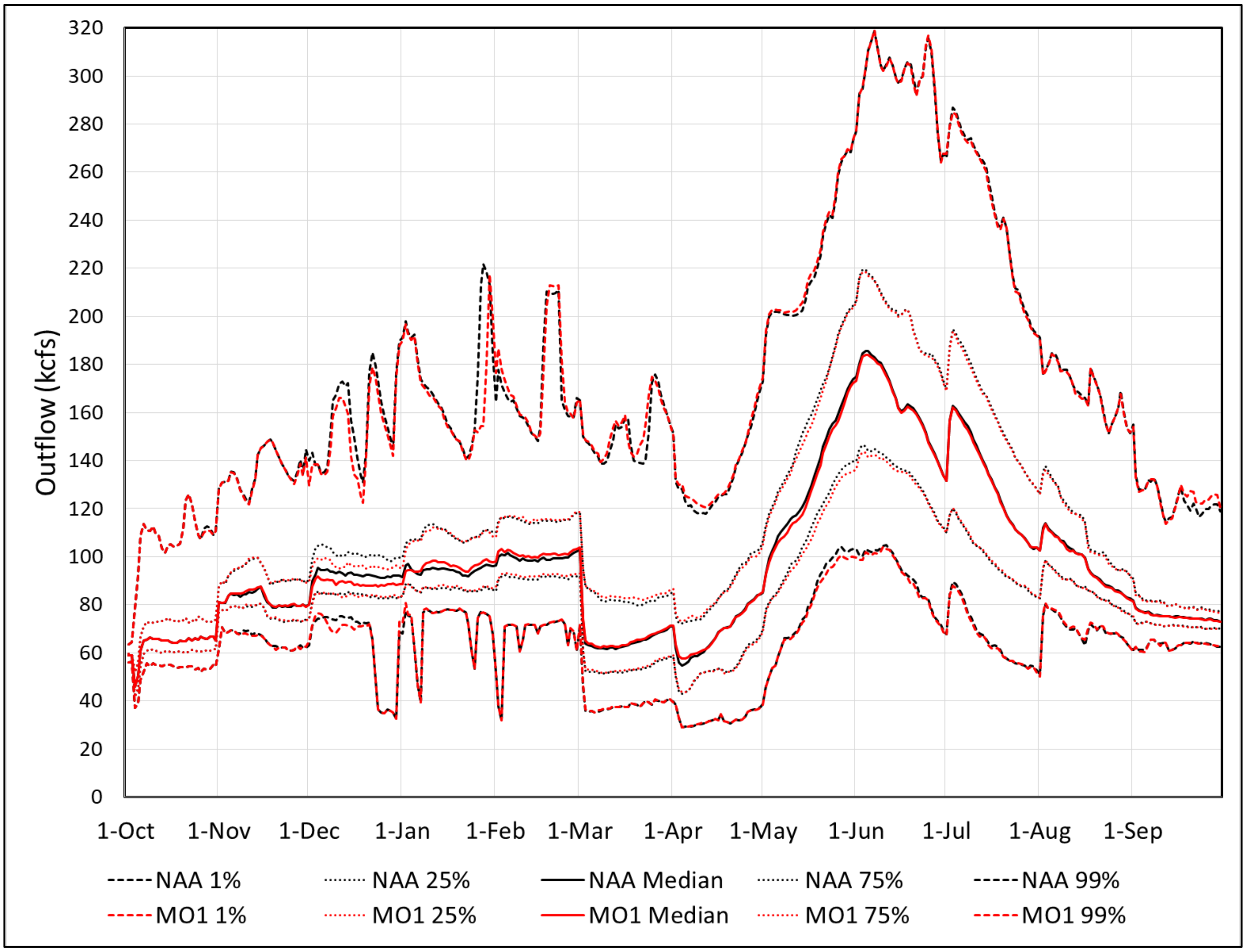



**Figure 3-29. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 1**

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

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

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

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

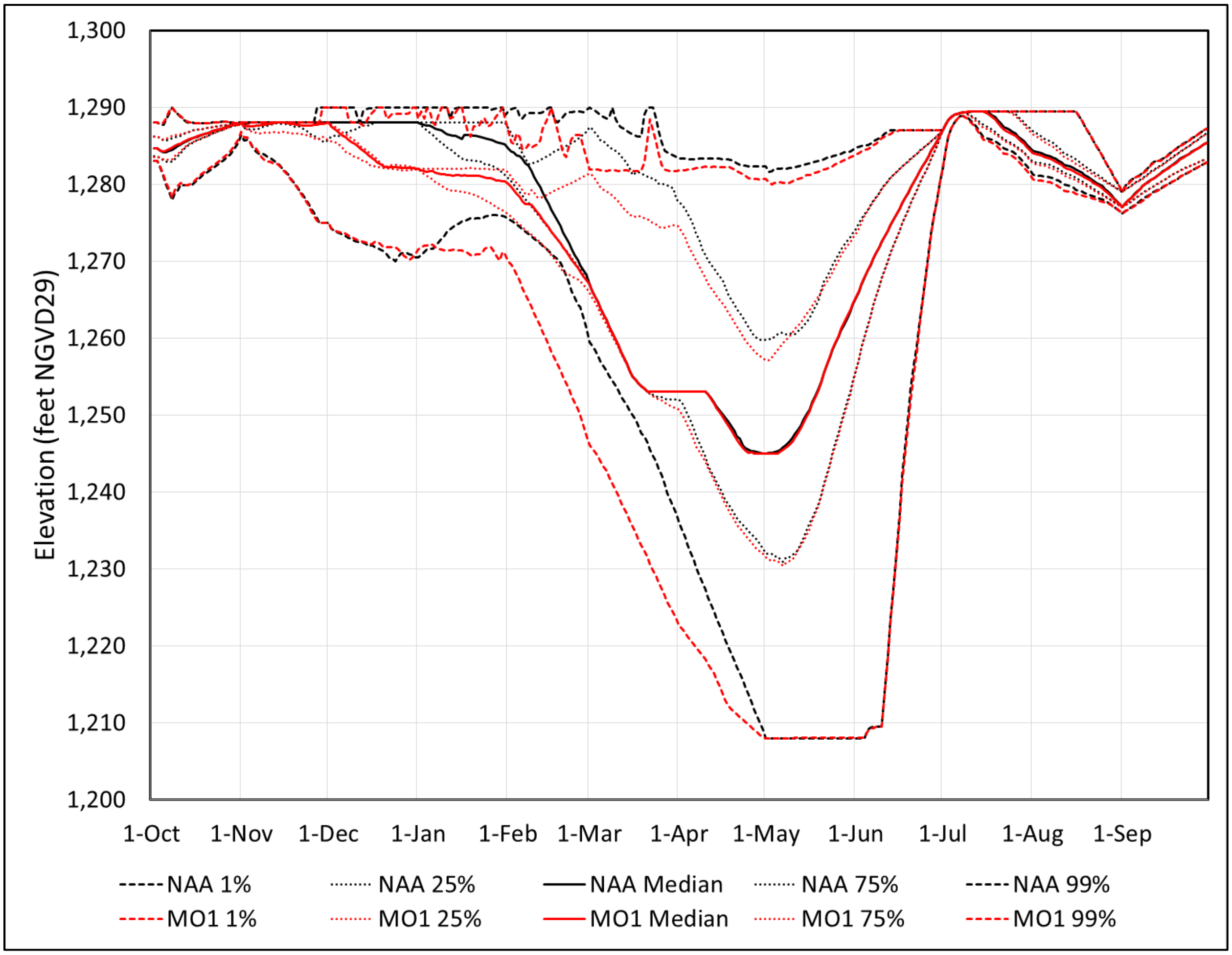



**Figure 3-30. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 1**

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

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

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

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

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

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

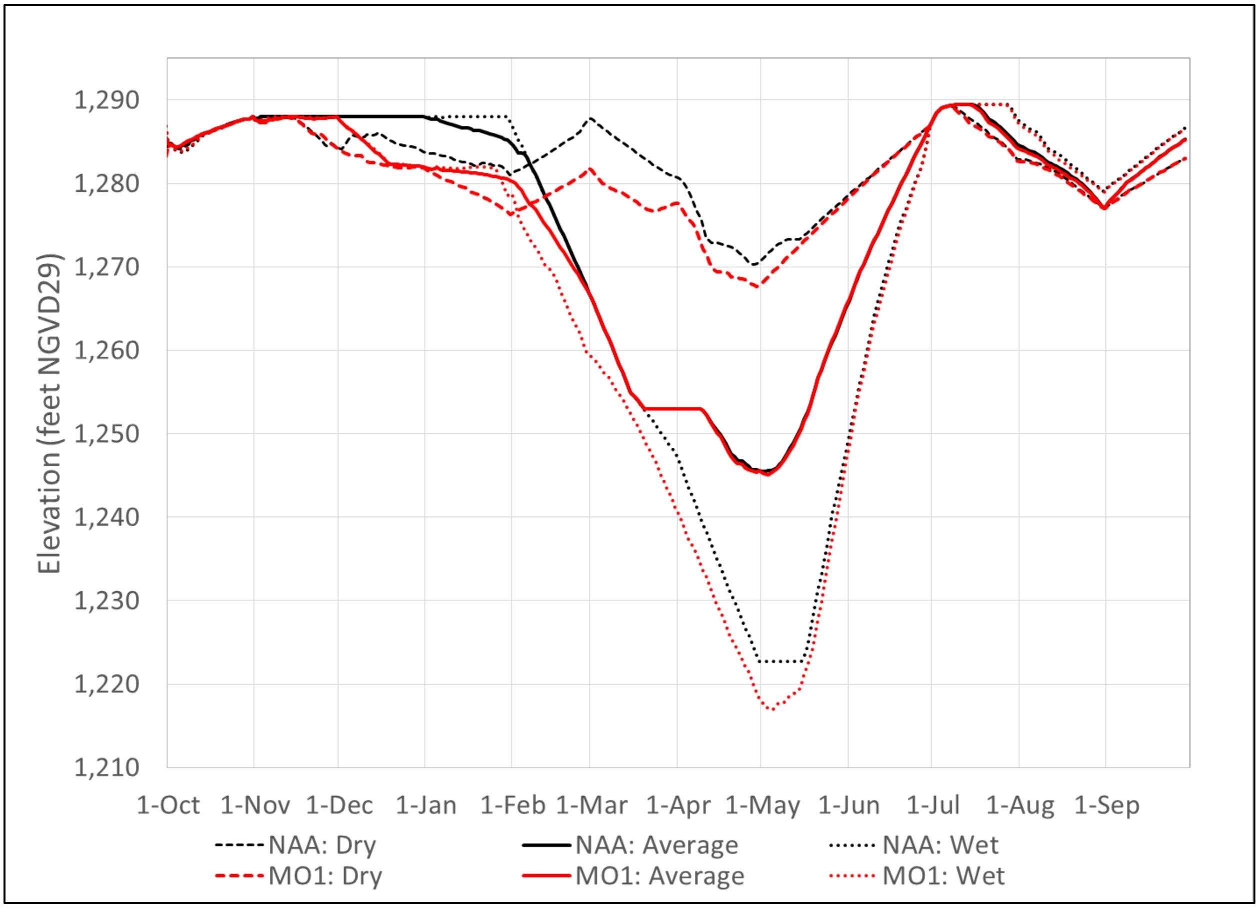



**Figure 3-31. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 1**

**Grand Coulee Dam Drum Gate Maintenance**

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

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

### Grand Coulee Dam Outflow

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

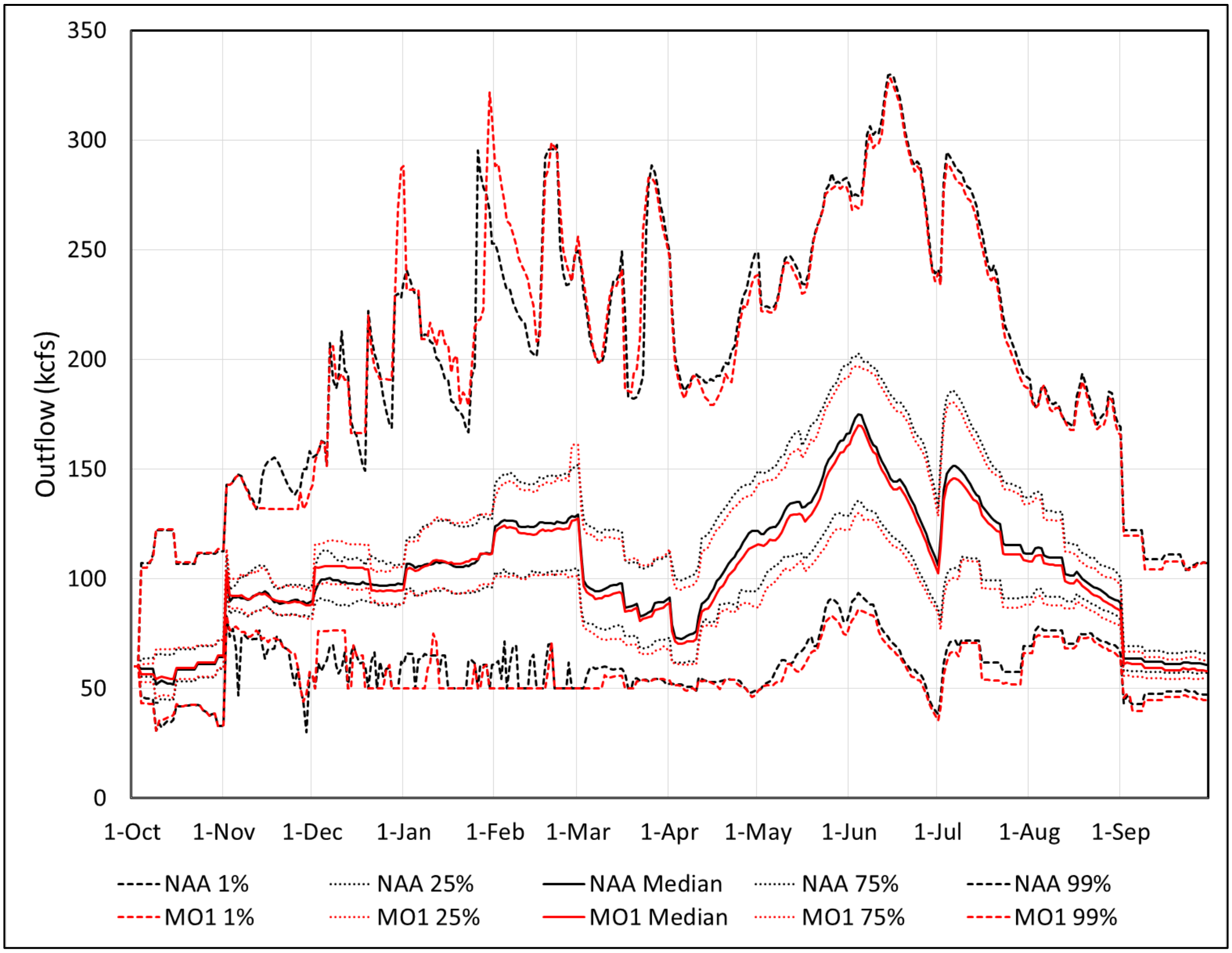



**Figure 3-32. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 1**

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

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

**Table 3-14. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 1 (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% |

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

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

- In December, the median value of the monthly average outflow would increase by 3.8 kcfs, primarily due to the *Winter System FRM Space* measure which creates winter FRM space in Grand Coulee's reservoir.
- In January, the median value of the monthly average outflow would increase by 0.6 kcfs. This may be caused by the *Winter System FRM Space* measure, which continues to draft Grand Coulee's reservoir in January if the winter FRM space is not achieved by the end of December. The *Update System FRM Calculation* and *Planned Draft Rate at Grand Coulee* measures can also influence flows in January.
- The *Planned Draft Rate at Grand Coulee* measure would reduce the designed draft rate for the Grand Coulee Dam Storage Reservation Diagram (SRD), which aims to initiate the system FRM draft earlier in the winter. However, the *Winter System FRM Space* measure would have a larger effect on the winter releases as even with the earlier draft targets, Grand Coulee Dam's median average outflow in February and March would be reduced by 2.5 and 2.3 kcfs, respectively.
- In February and March, the median value of the monthly average outflow would decrease by 2.5 and 2.3 kcfs, respectively.
- In April the volume of water to be pumped from Lake Roosevelt into Banks Lake would increase due to the *Lake Roosevelt Additional Water Supply* measure. The April through

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

- In April, the median value of the monthly average outflow would decrease by 4.6 kcfs; the *Lake Roosevelt Additional Water Supply* measure's increased pumping from Lake Roosevelt into Banks Lake accounts for the majority (3.2 kcfs) of this decrease. The *Update System FRM Calculation* and *Planned Draft Rate at Grand Coulee* measures, as well as changes to inflow from measures changing operations at upstream storage projects, would also affect Grand Coulee Dam outflows in April.
- The median value of the monthly average outflow would decrease by 6.1 and 4.5 kcfs for May and June, respectively. The *Lake Roosevelt Additional Water Supply* measure's increased pumping from Lake Roosevelt into Banks Lake accounts for the majority of this outflow reduction, but not all of it. The *Lake Roosevelt Additional Water Supply* measure would decrease outflows by 3.2 and 3.0 kcfs in May and June, respectively. The *Update System FRM Calculation* measure and changes to inflow from operational measures changing operations at upstream storage projects, would also affect flows in May and June.
- In July, August, and September, the median value of the monthly average outflow would be reduced by 4.6, 3.4, and 3.0 kcfs, respectively. This is almost exclusively due to the *Lake Roosevelt Additional Water Supply* measure. The *Lake Roosevelt Additional Water Supply* measure would decrease flows by 4.2, 2.6, and 2.5 kcfs in July, August, and September respectively.
- The *Grand Coulee Maintenance Operations* measure would not impact reservoir elevations or total outflows, but would reduce the hydraulic capacity through the power plants, resulting in additional spill and an increase in TDG in some situations.

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

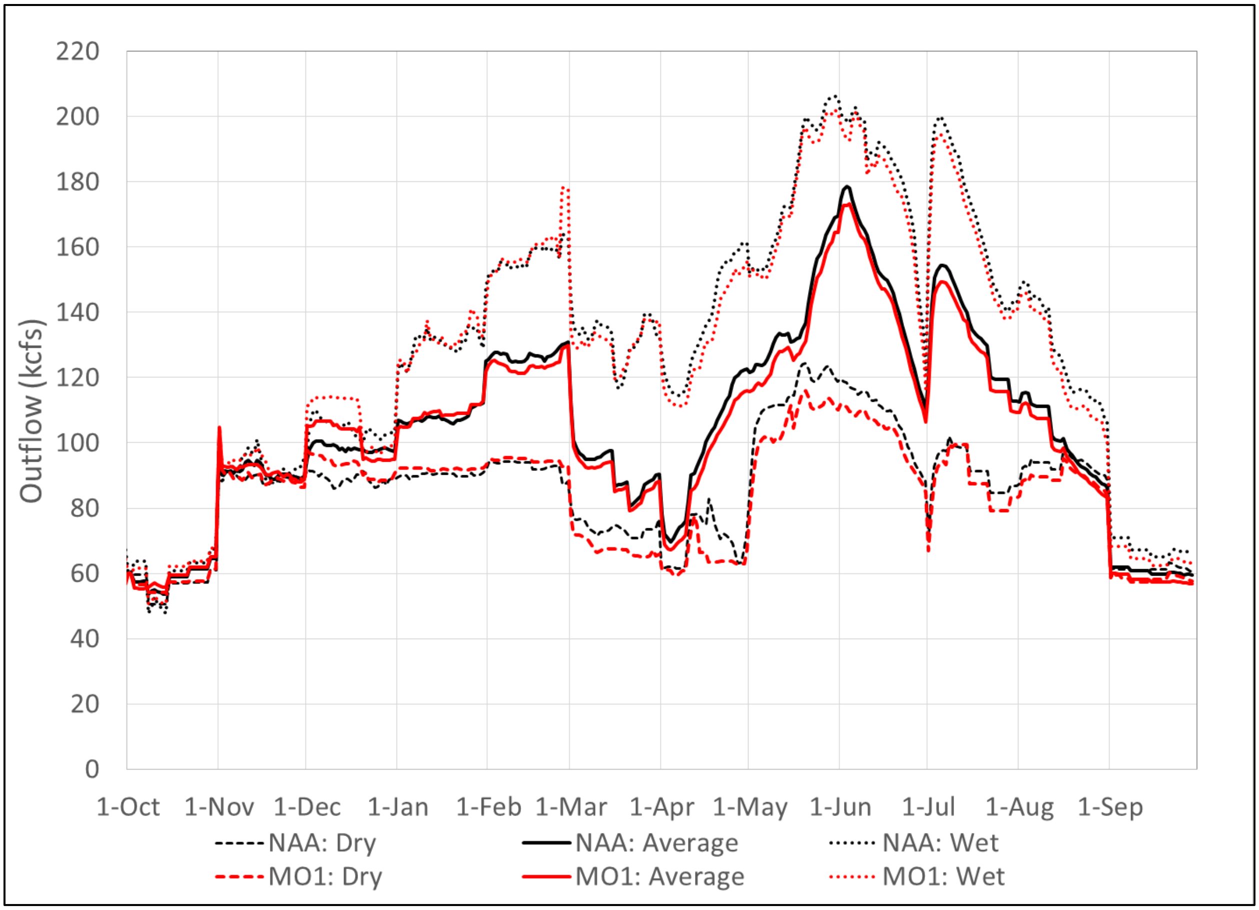



**Figure 3-33. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1**

**Middle Columbia River below Grand Coulee Dam**

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

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

**Table 3-15. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative 1 (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 | 0.0 | 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% |

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

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Dworshak Reservoir Elevation

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

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

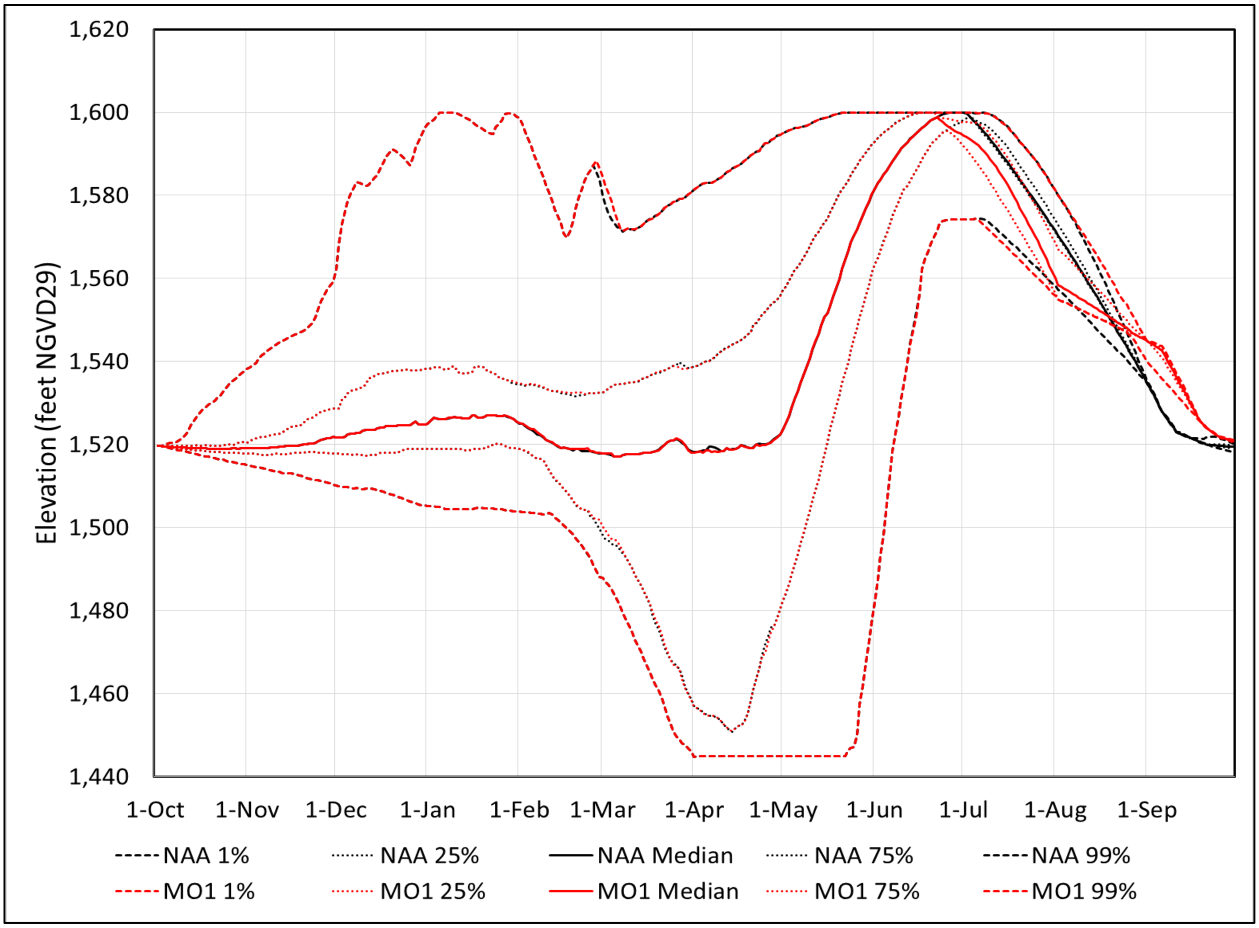



**Figure 3-34. Dworshak Reservoir Summary Hydrograph for Multiple Objective Alternative 1**

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

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

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

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

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

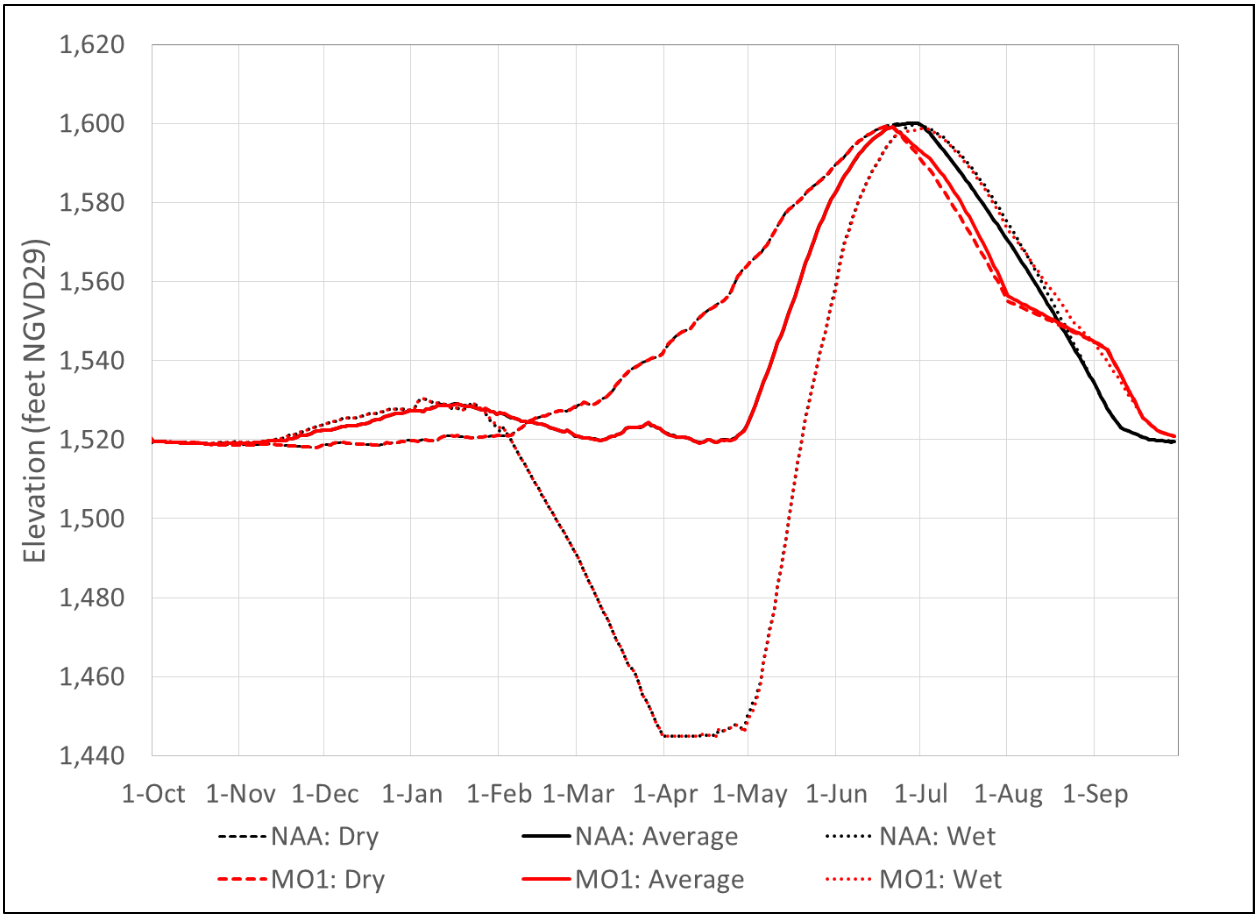



**Figure 3-35. Dworshak Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 1**

**Dworshak Dam Outflow**

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

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

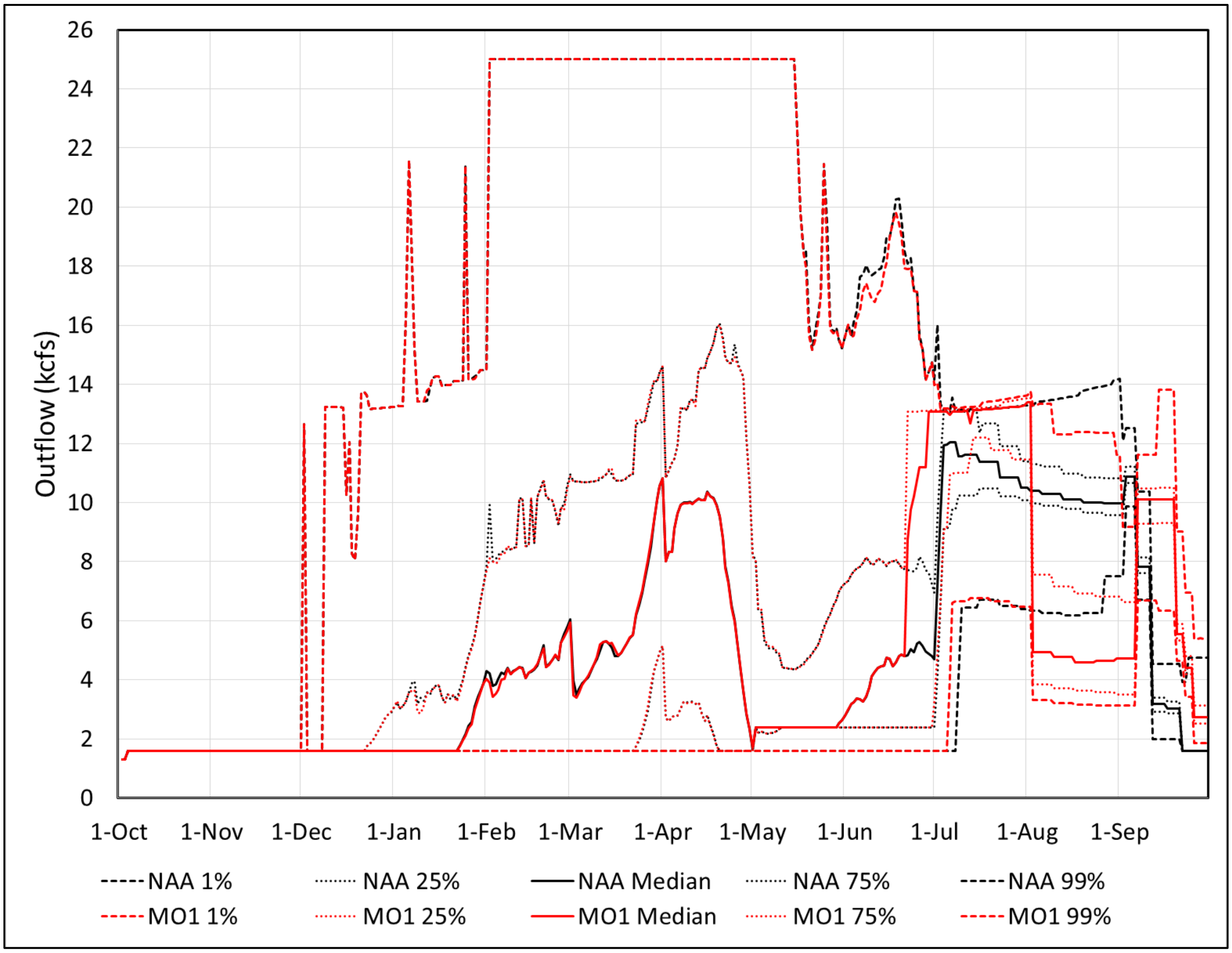



**Figure 3-36. Dworshak Dam Outflow Summary Hydrograph for Multiple Objective Alternative 1**

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

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

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

**Table 3-16. Dworshak Dam Monthly Average Outflow for Multiple Objective Alternative 1 (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% | 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 | 7.4 | 9.3 | 4.5 |
| 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% |

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

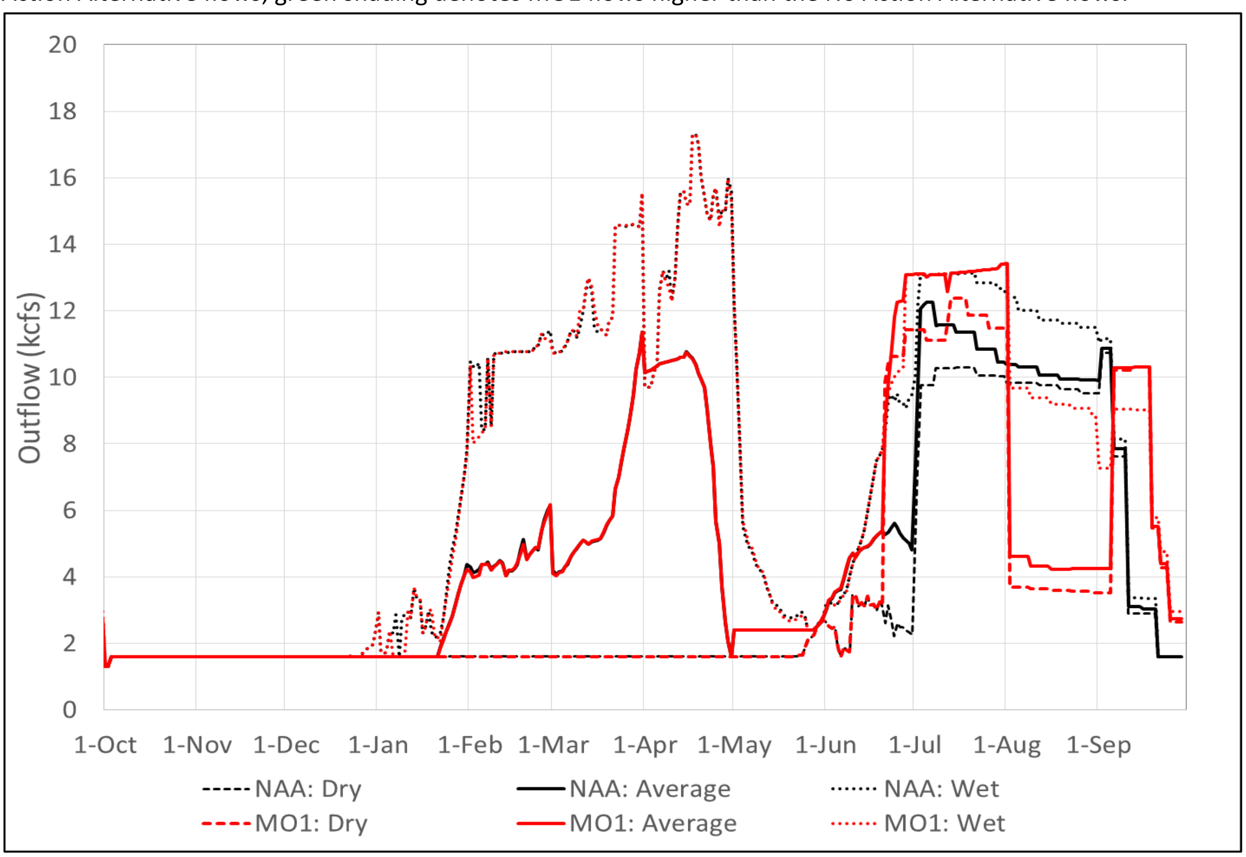



**Figure 3-37. Dworshak Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1**

### Lower Snake River Reservoir Elevations

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

- Lower Granite Dam: 733.0 to 734.5 feet NGVD29, compared to 733.0 to 734.0 feet NGVD29 for No Action Alternative
- Little Goose Dam: 633.0 to 634.5 feet NGVD29, compared to 633.0 to 634.0 feet NGVD29 for No Action Alternative
- Lower Monumental Dam: 537.0 to 538.5 feet NGVD29, compared to 537.0 to 538.0 feet NGVD29 for No Action Alternative
- Ice Harbor Dam: 437.0 to 438.5 feet NGVD29, compared to 437.0 to 438.0 feet NGVD29 for No Action Alternative.

### Clearwater River below Dworshak Dam and the Lower Snake River

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

**Table 3-17. Lower Snake Basin Monthly Average Flows for Multiple Objective Alternative 1 (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% |

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

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

### Lower Columbia River Reservoir Elevations

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

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

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

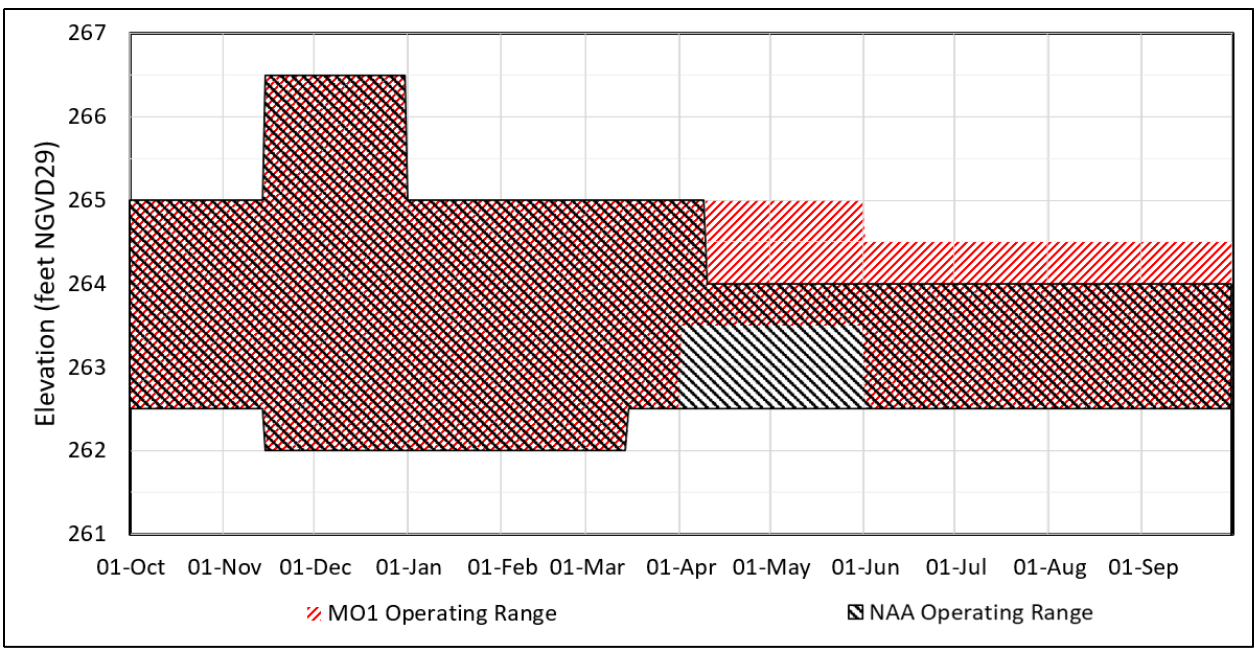



**Figure 3-38. John Day Dam Operating Range for Multiple Objective Alternative 1**

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

**Lower Columbia River Flows**

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

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

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

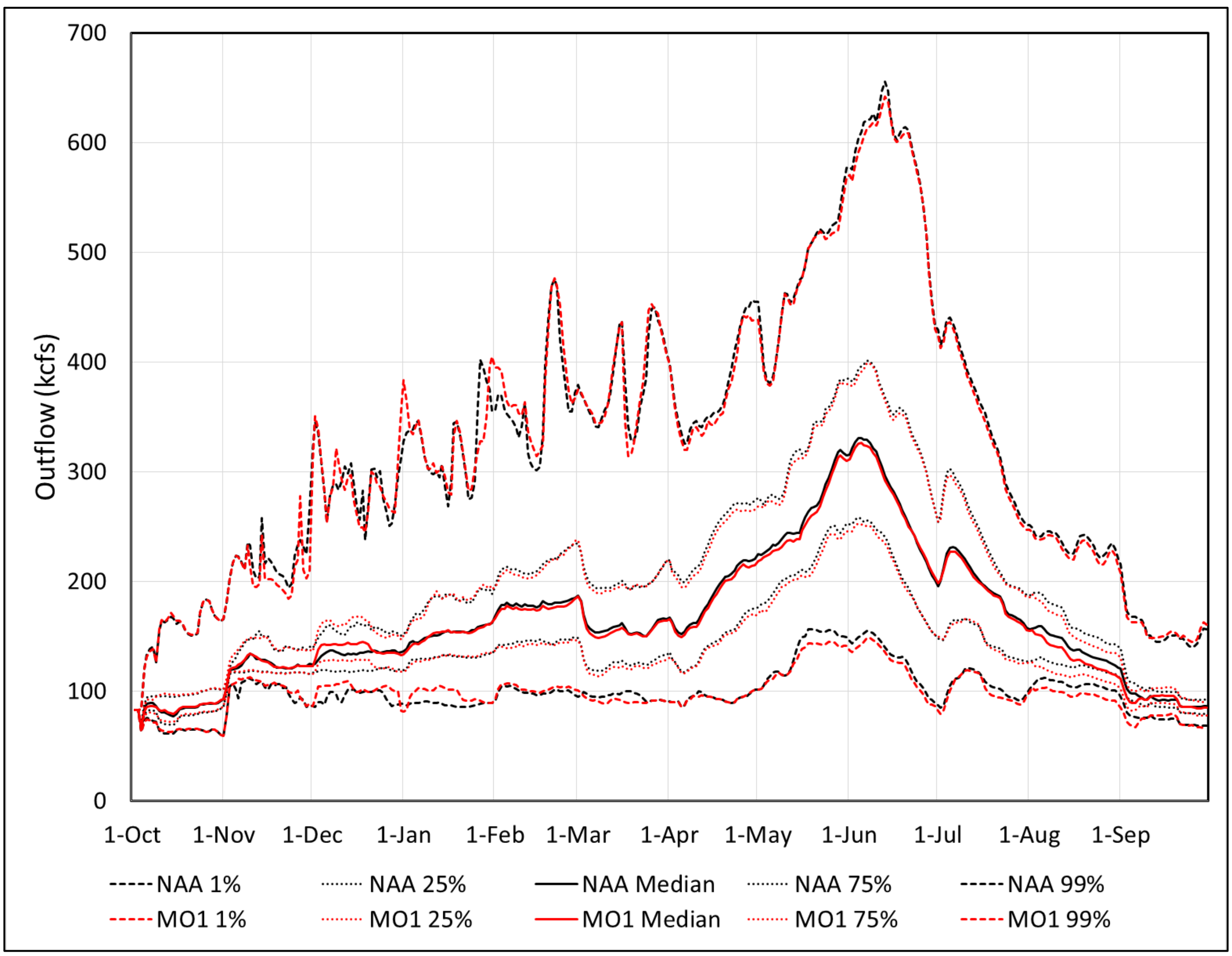



**Figure 3-39. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 1**

- In December, the median value of the monthly average outflow would increase by 4.5 kcfs. A combination of measures would cause this, with the *Winter System FRM Space* measure being the main reason for the flow increases.
- In August, the median value of the monthly average outflow would decrease by 8.5 kcfs. A combination of measures would cause this. The *Modified Dworshak Summer Draft* measure at Dworshak Dam (modifying the timing of water releases in the summer), the *Lake Roosevelt Additional Water Supply* measure at Grand Coulee Dam (increasing the volume of water pumped from Lake Roosevelt into Banks Lake), the *Hungry Horse Additional Water Supply* measure on the Flathead River (reducing flows below Flathead Lake by approximately 0.5 kcfs), and the *Sliding Scale at Libby and Hungry Horse* measure at Libby Dam (changing the end of September target reservoir elevation) would all play a role in this flow reduction, as would several of the other measures.

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

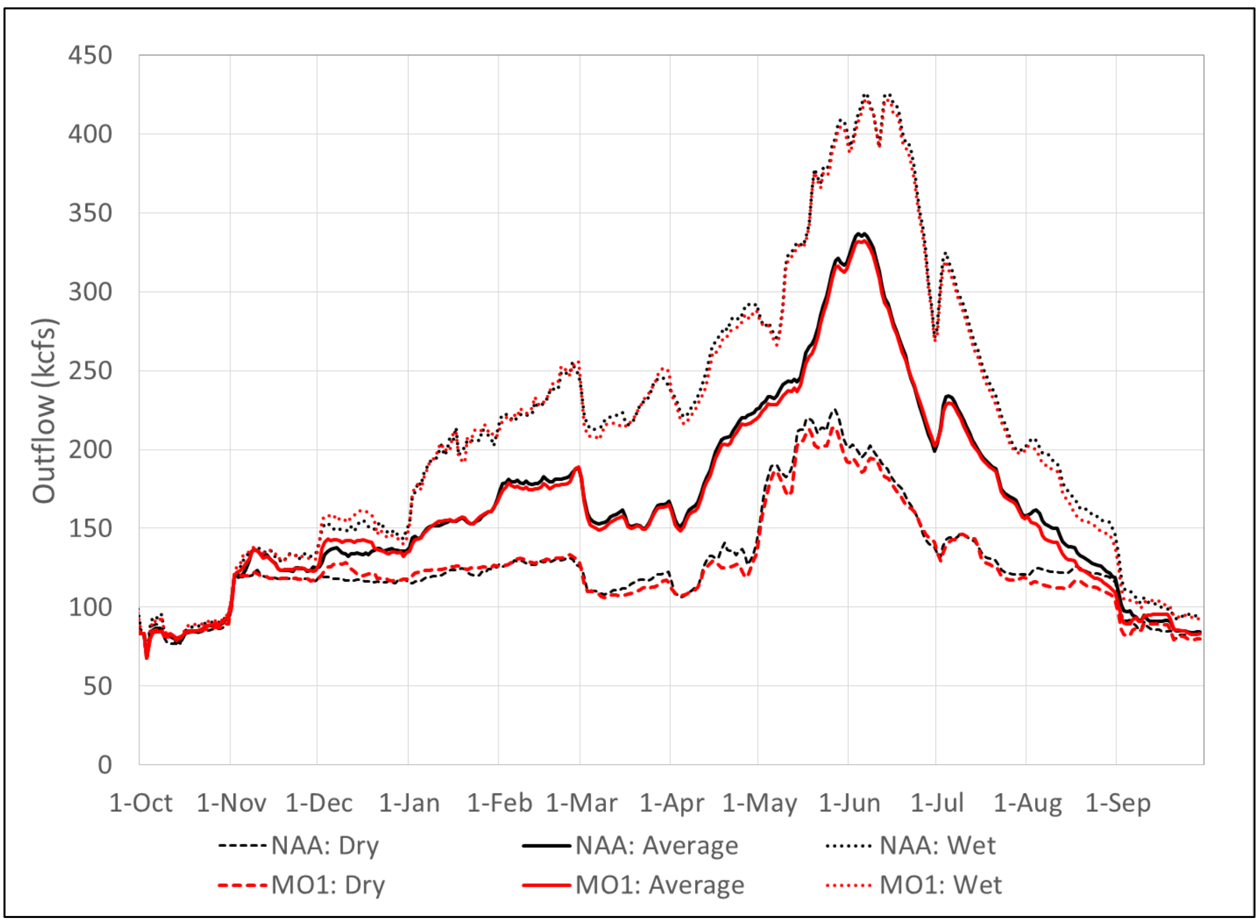



**Figure 3-40. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 1**

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

**Table 3-18. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 1 (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% |

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

## SUMMARY OF EFFECTS

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

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

#### *3.2.4.5 Multiple Objective Alternative 2*

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

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

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

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

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

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

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

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

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

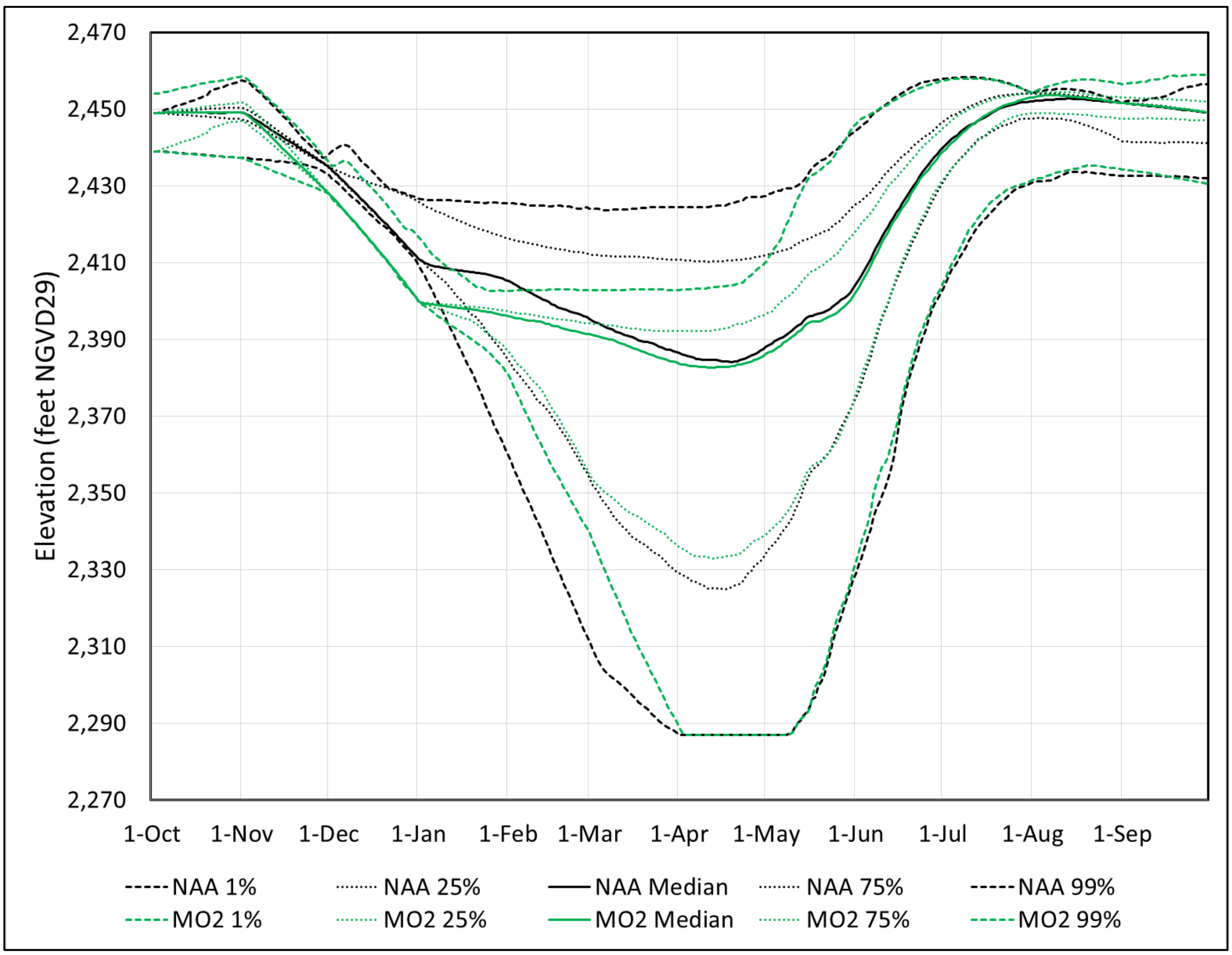



**Figure 3-41. Lake Koocanusa Summary Hydrograph for Multiple Objective Alternative 2**

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

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

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

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

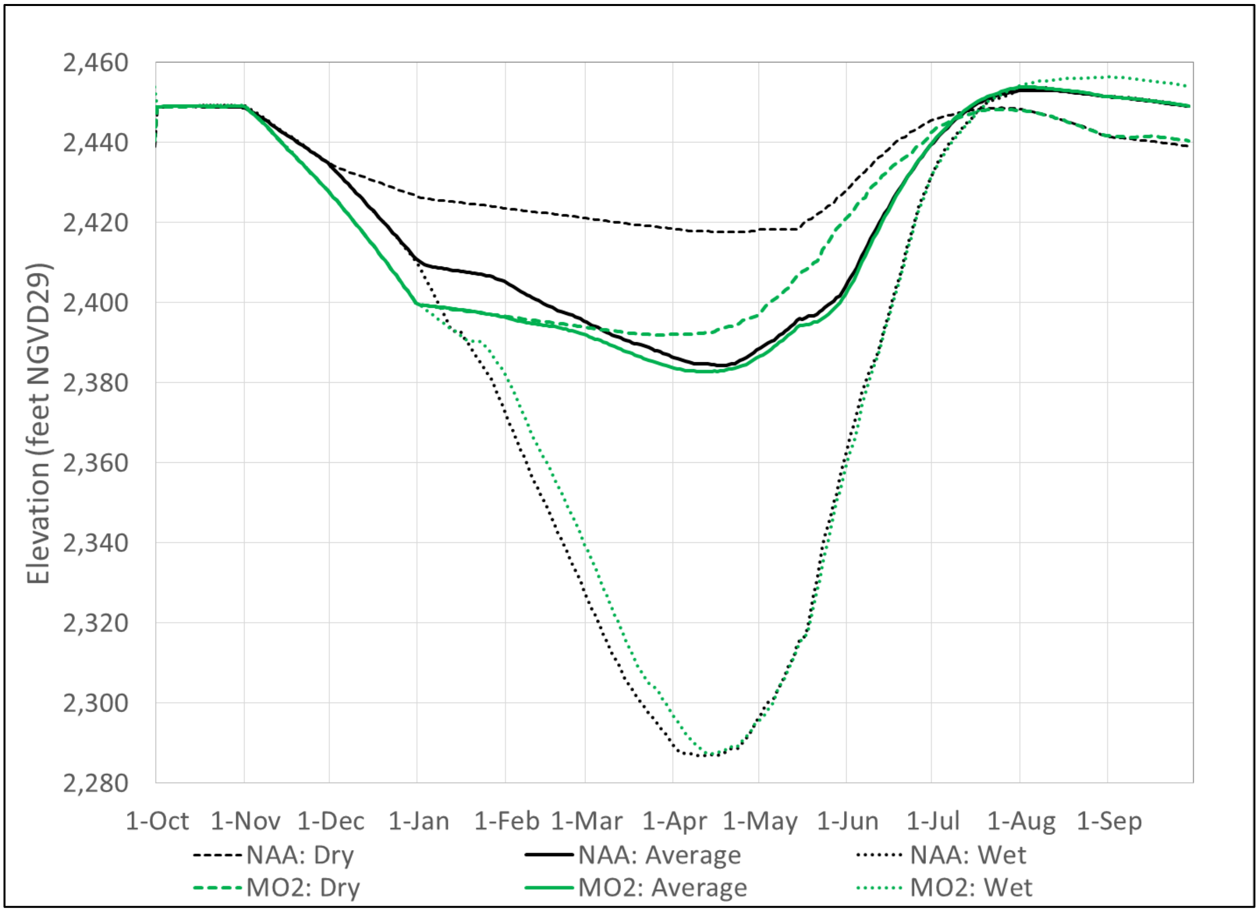



**Figure 3-42. Lake Koocanusa Water Year Type Hydrographs for Multiple Objective Alternative 2**

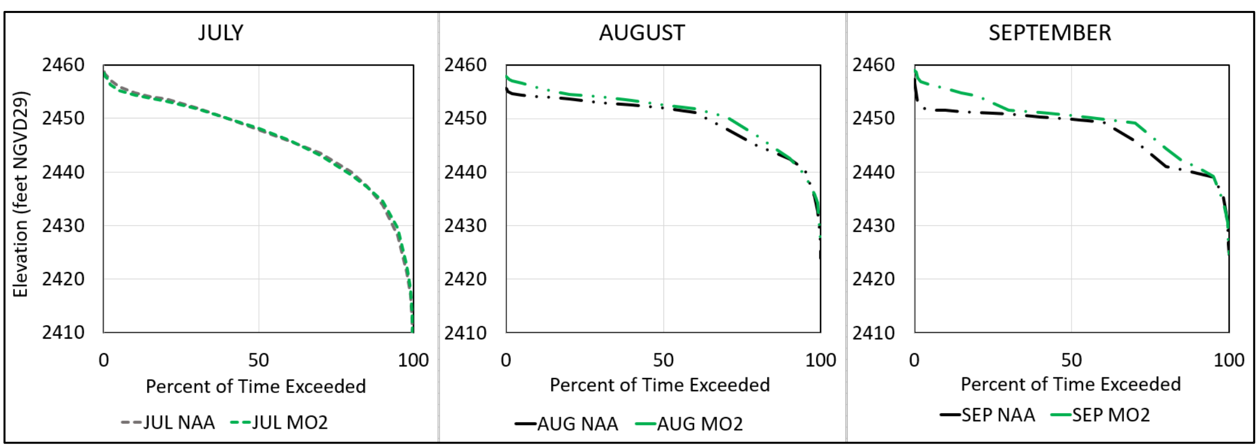



**Figure 3-43. Lake Koocanusa Summer Elevations for Multiple Objective Alternative 2**

**Libby Dam Outflow**

Under MO2, the *Ramping Rates for Safety*, *Slightly Deeper Draft for Hydropower*, *Sliding Scale at Libby and Hungry Horse*, *Modified Draft at Libby*, and *December Libby Target Elevation* measures would have a direct effect on Libby Dam outflow. As seen in Figure 3-44, the change in outflows from the No Action Alternative varies throughout the year. Figure 3-44 shows median hydrographs for Libby Dam outflow in dry, average, and wet years.

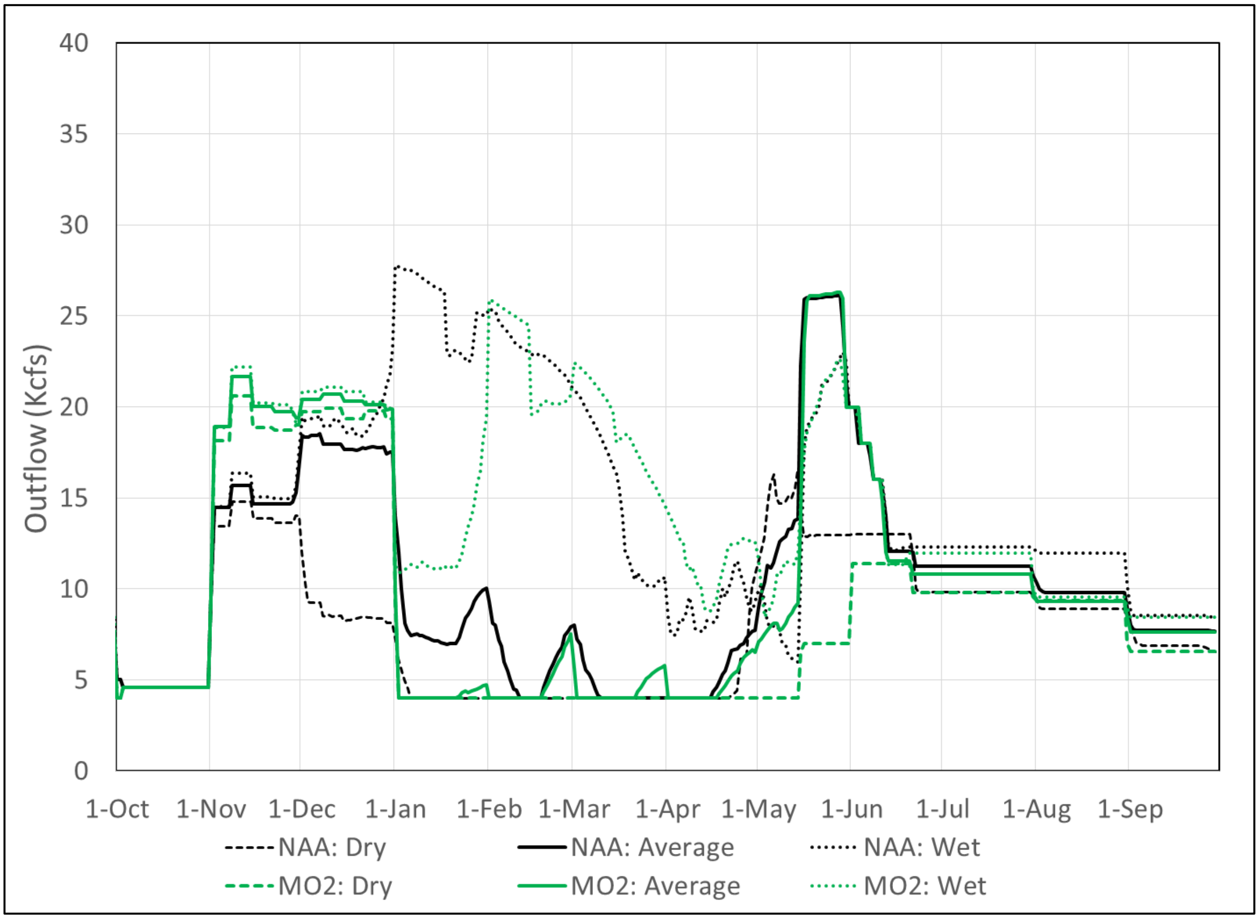



**Figure 3-44. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2**

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

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

**Table 3-19. Libby Dam Monthly Average Outflow for Multiple Option Alternative 2 (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% | 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% |

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

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

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

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

### Bonners Ferry Flow

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

**Table 3-20. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 2 (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% | 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% |

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

### Hungry Horse Reservoir Elevation

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

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

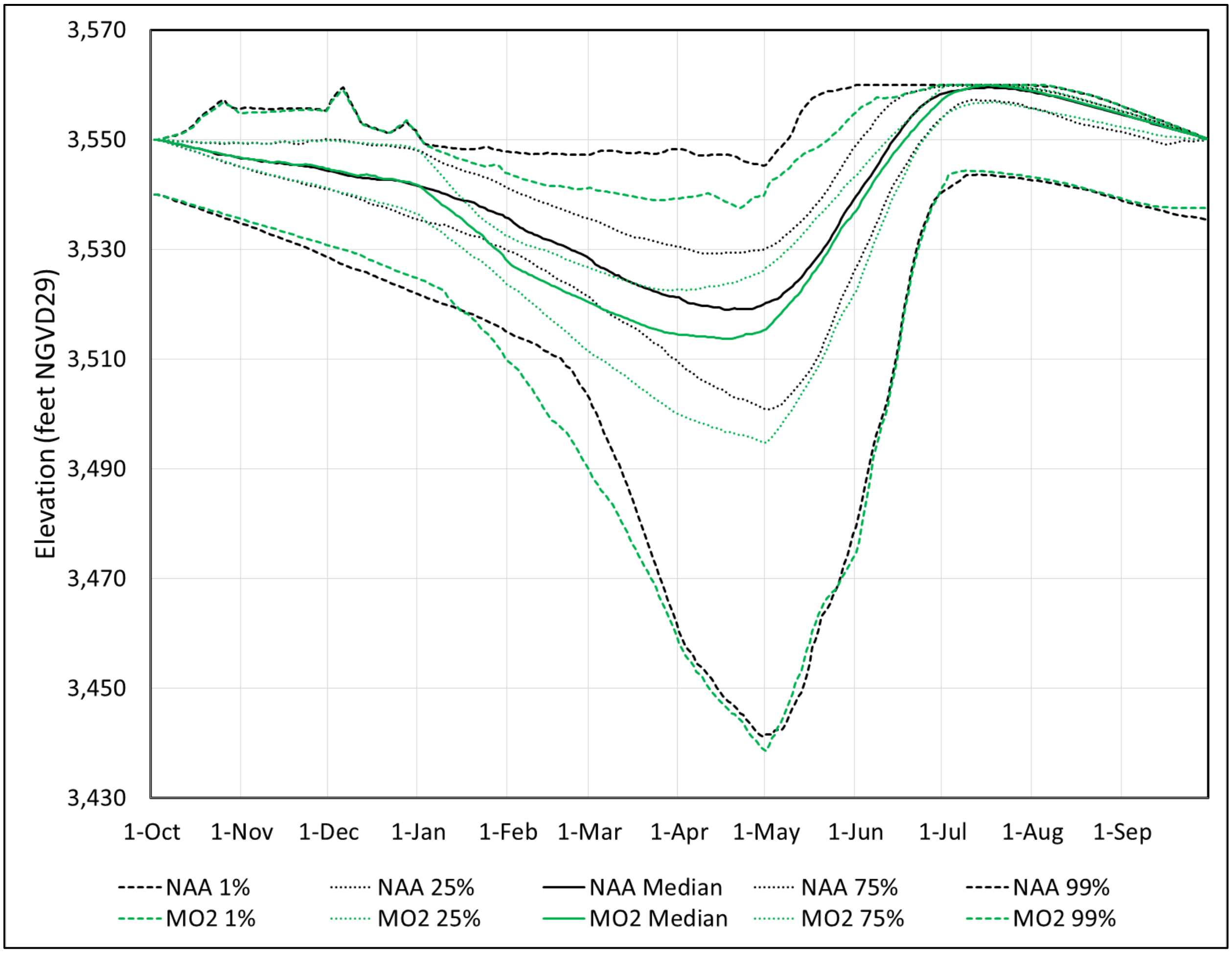



**Figure 3-45. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 2**

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

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

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

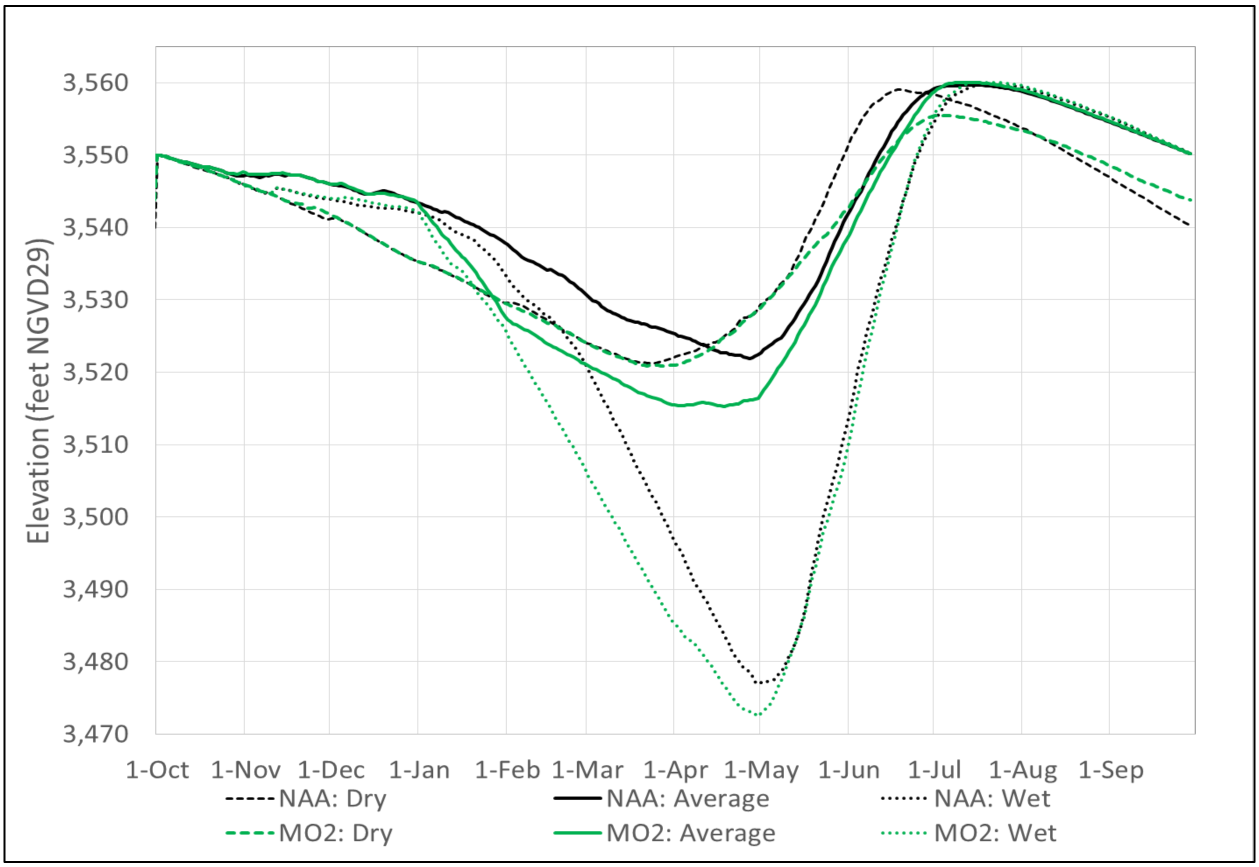



**Figure 3-46. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 2**

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

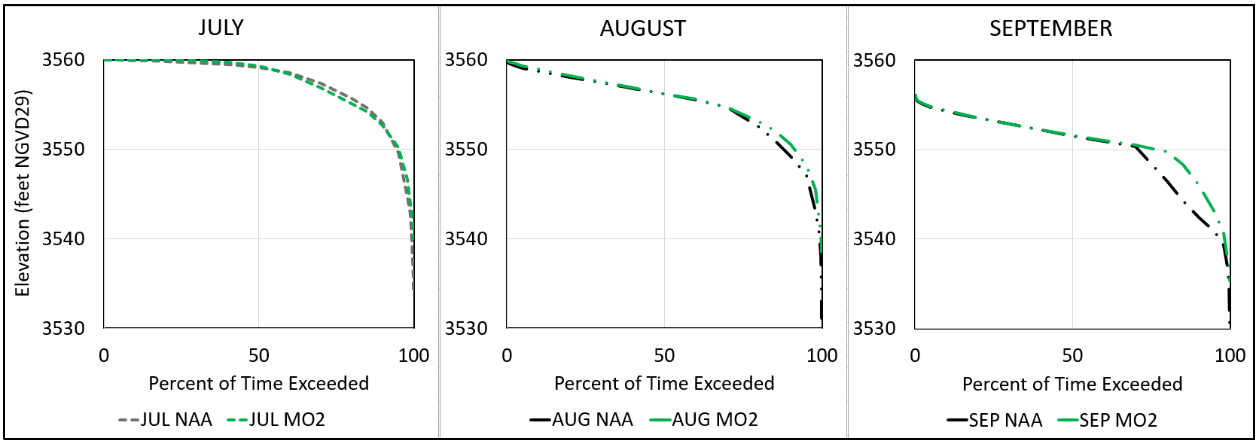



**Figure 3-47. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 2**

### Hungry Horse Dam Outflow

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

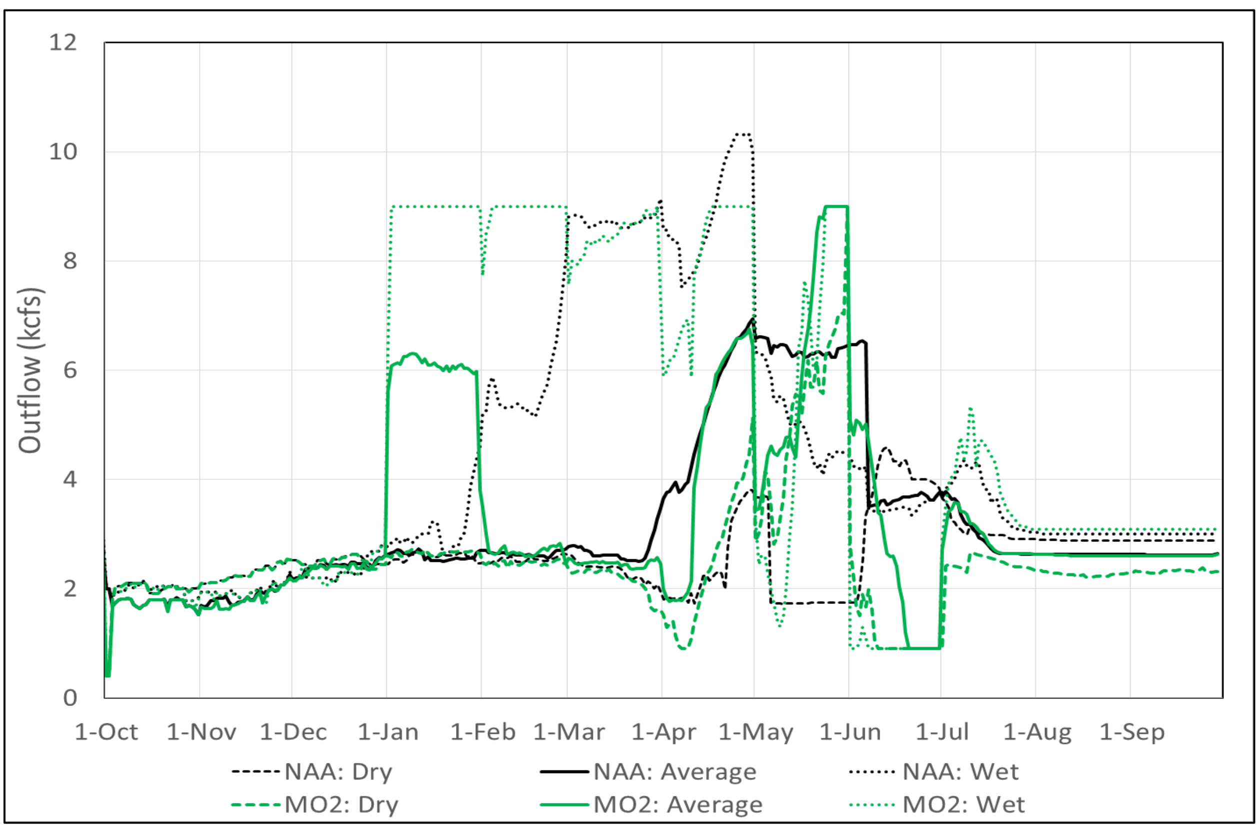



**Figure 3-48. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2**

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

**Table 3-21. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 2 (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 | 1.8 | 1.9 | 2.0 |
| 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% |

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

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

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

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

**Columbia Falls Flow**

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

**Table 3-22. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 2 (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% | 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 (kcfs) | 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% |

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

**Lake Pend Oreille Elevation**

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

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

### Albeni Falls Outflow

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

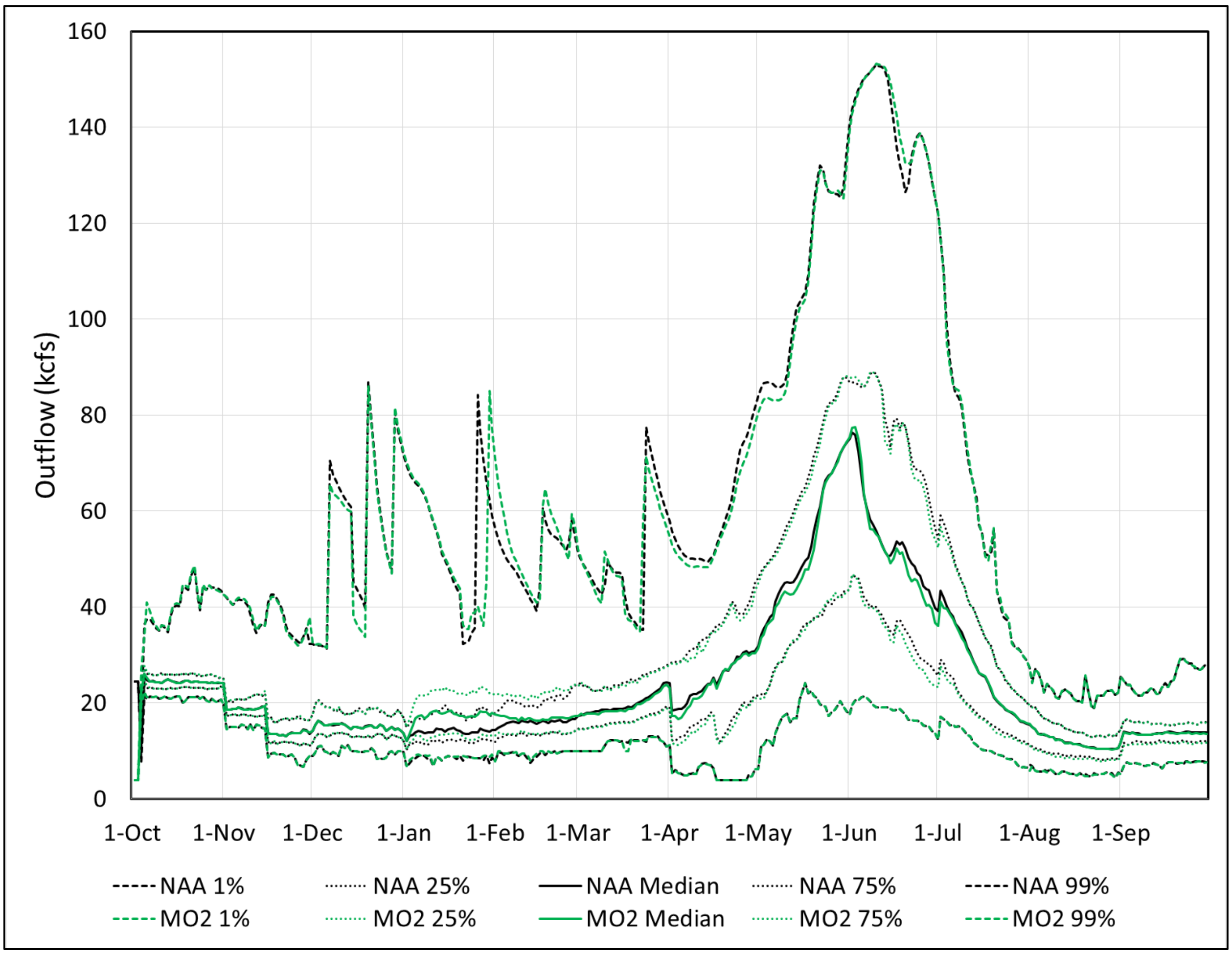



**Figure 3-49. Albeni Falls Dam Outflow Summary Hydrograph for Multiple Objective Alternative 2**

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

**Table 3-23. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 2 (as 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% |

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

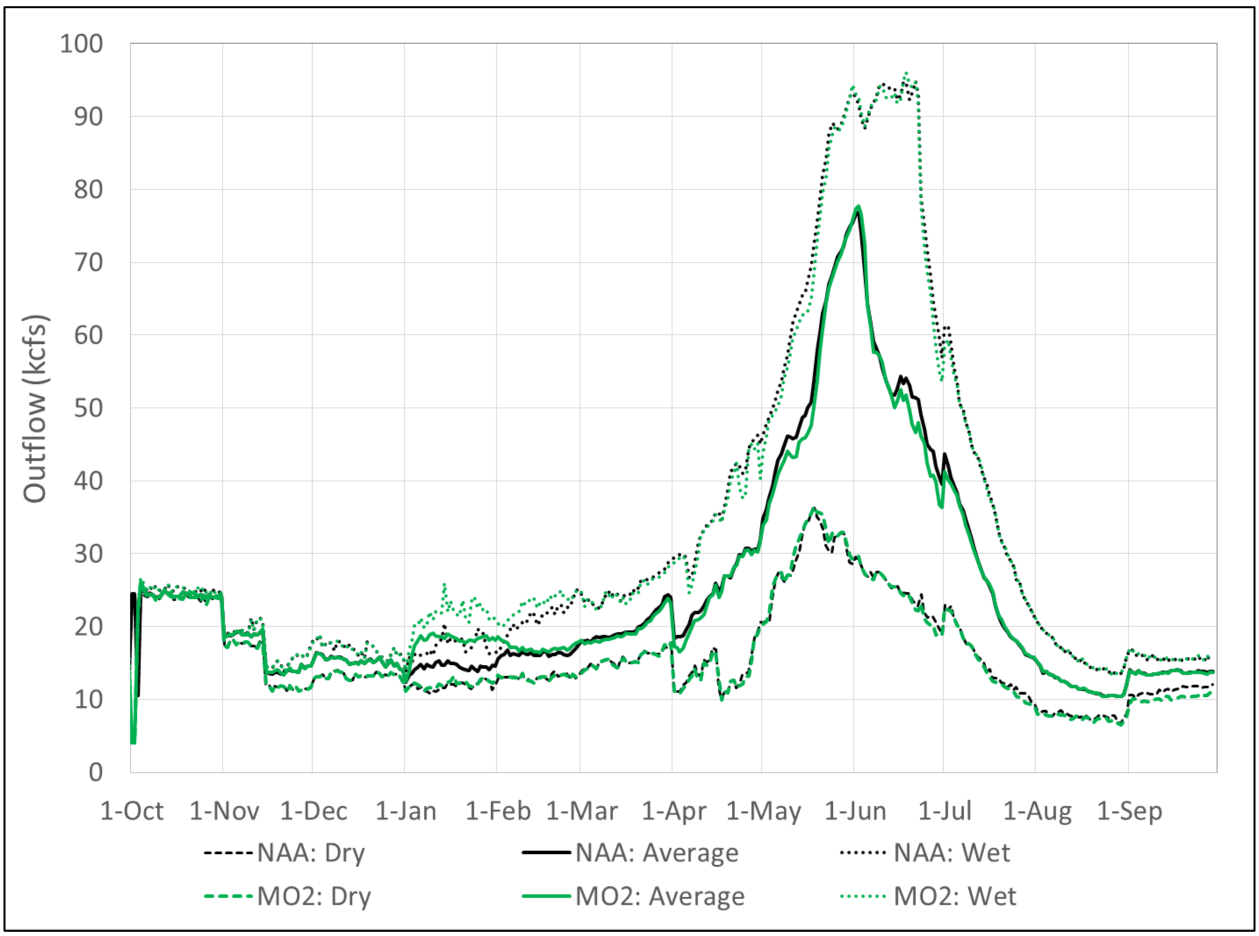



**Figure 3-50. Albeni Falls Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2**

In January, the median value of the monthly average outflow from Albeni Falls Dam would be 3.2 kcfs higher than the No Action Alternative. In February, it would be 1.0 kcfs higher than the No Action Alternative. Following that, the months of March, April, May, and June would all have lower outflows. The January to February flow increases and the March to June flow decreases are all attributable to the *Slightly Deeper Draft for Hydropower* measure at Hungry Horse Dam.

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

### REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

#### Columbia River Flow Upstream of Grand Coulee Dam

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

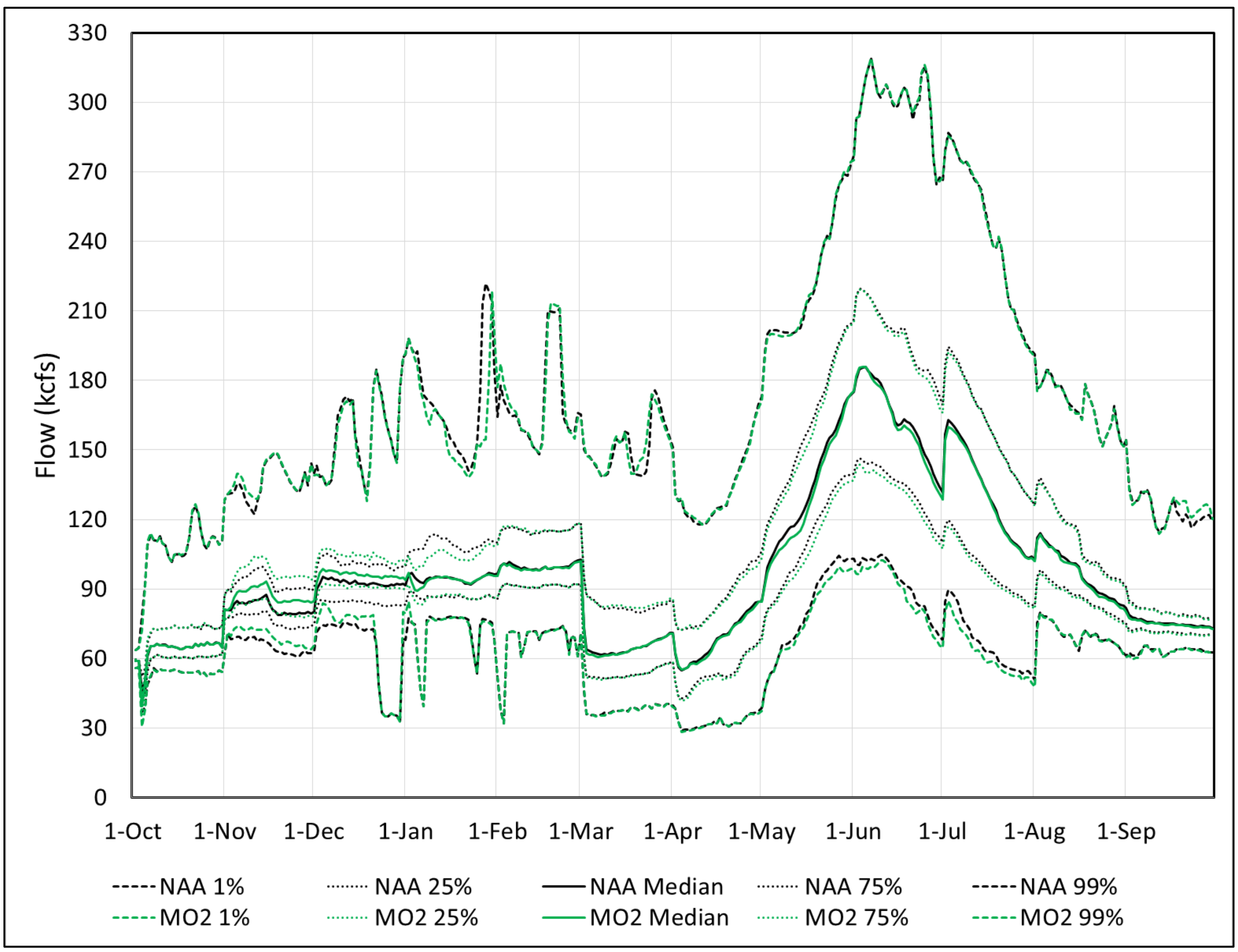



**Figure 3-51. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 2**

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

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

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

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

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

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

The lower reservoir elevations in October are primarily caused by the *Slightly Deeper Draft for Hydropower* measure, which includes a minimum elevation of 1,283 feet NGVD29 at the end of October. (In the No Action Alternative, the target elevation of 1,283 feet NGVD29 is for the end of September for resident fish considerations.) From mid-December through January, the median monthly reservoir elevation would be about 5 feet lower under MO2 than for the No Action Alternative. This is primarily due to the *Winter System FRM Space* measure, which would increase the space available at Grand Coulee Dam for FRM in the winter months when rain-induced floods may occur as well as the *Slightly Deeper Draft for Hydropower* measure, which drafts the project more deeply for hydropower in January of the wettest years. In February, the reservoir would be lower than the No Action Alternative, primarily due to the *Slightly Deeper Draft for Hydropower* and *Planned Draft Rate at Grand Coulee* measures. By March 1, the median reservoir levels for MO2 realign with those in the No Action Alternative and match almost exactly from May through August. However, the wetter water years and drier water years would generally continue having lower reservoir elevations through March, April, and into May.

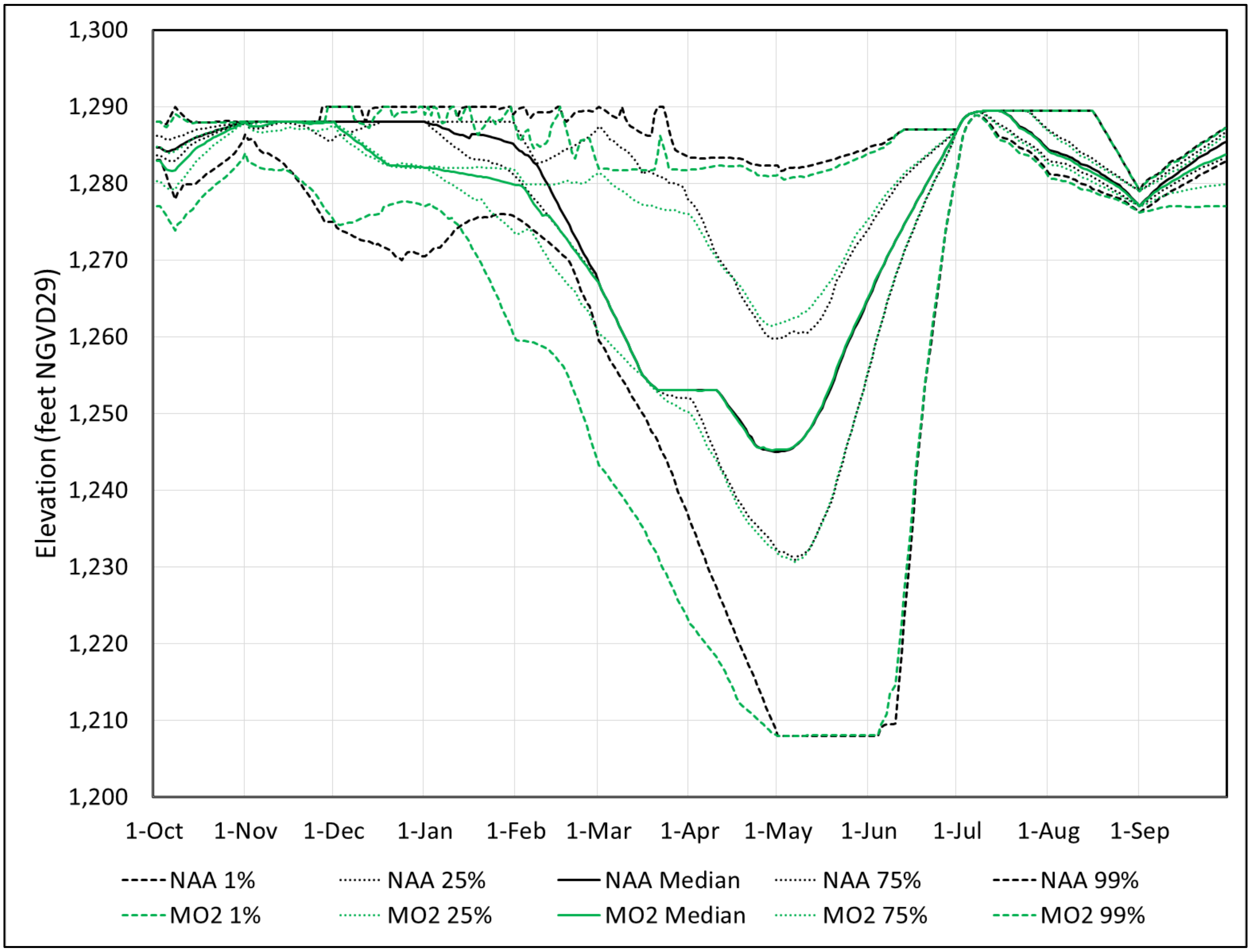



**Figure 3-52. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 2**

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

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

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

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

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

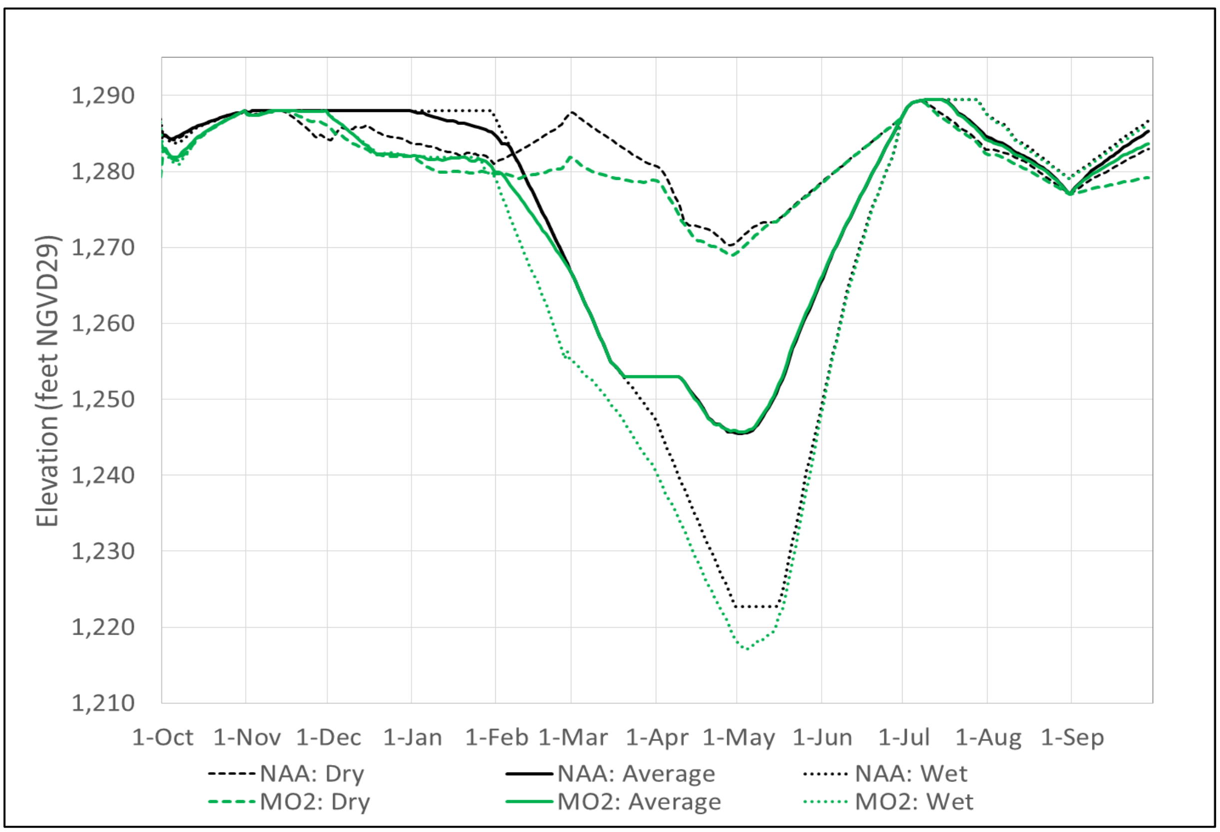



**Figure 3-53. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 2**

**Grand Coulee Dam Drum Gate Maintenance**

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

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

**Grand Coulee Dam Outflow**

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

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

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

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

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

Finally, Figure 3-55 shows median hydrographs for Grand Coulee Dam outflow in dry, average, and wet years. MO2 and the No Action Alternative are shown. The figure provides another way to picture the effects described above, this time categorized by water year type.

**Table 3-24. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 2 (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% |

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

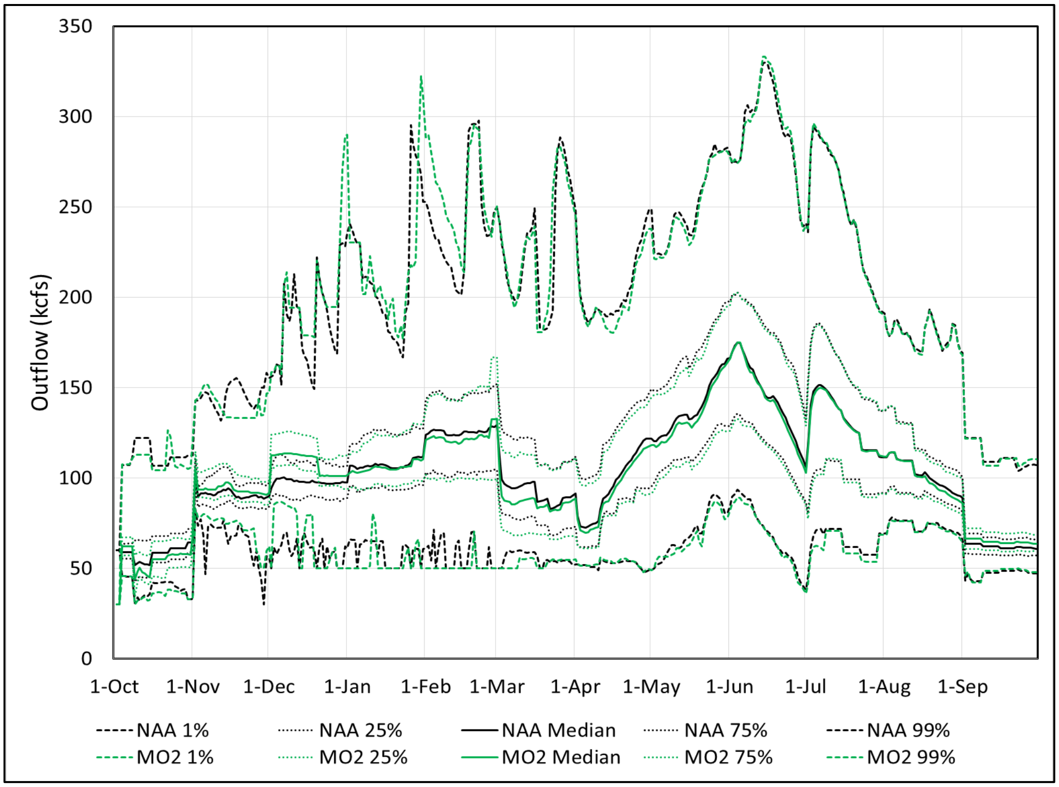



**Figure 3-54. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 2**

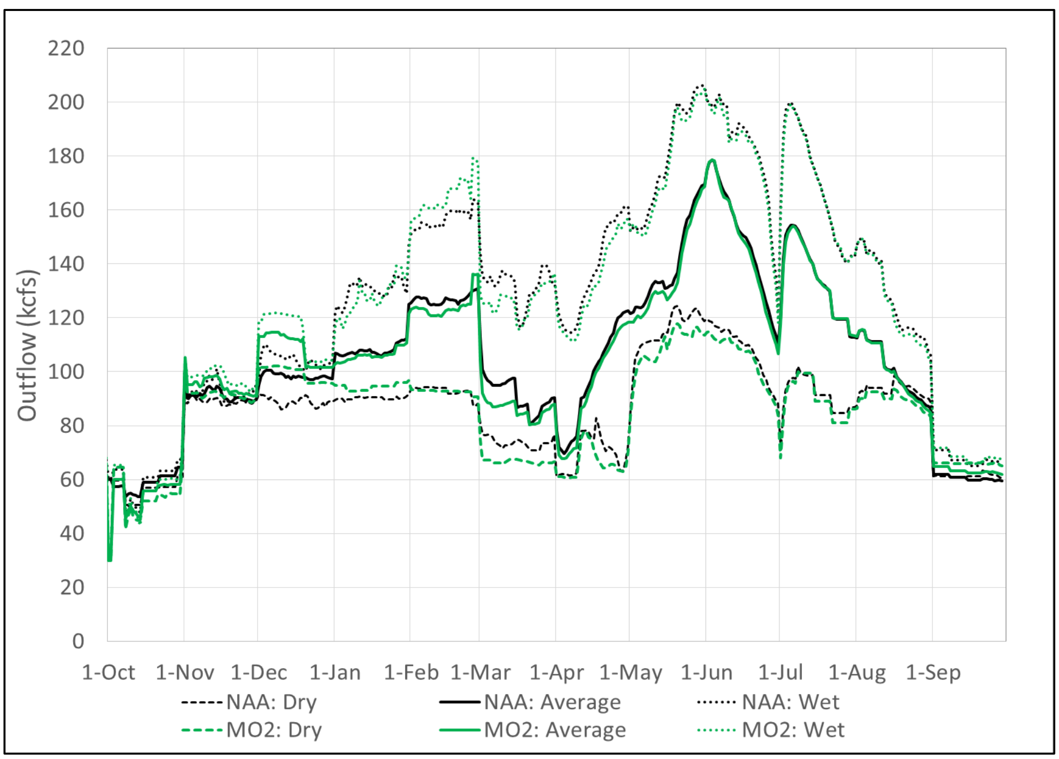



**Figure 3-55. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2**

### Middle Columbia River below Grand Coulee Dam

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

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

**Table 3-25. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative 2 (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 | 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% |

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

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Dworshak Dam

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

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

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

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

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

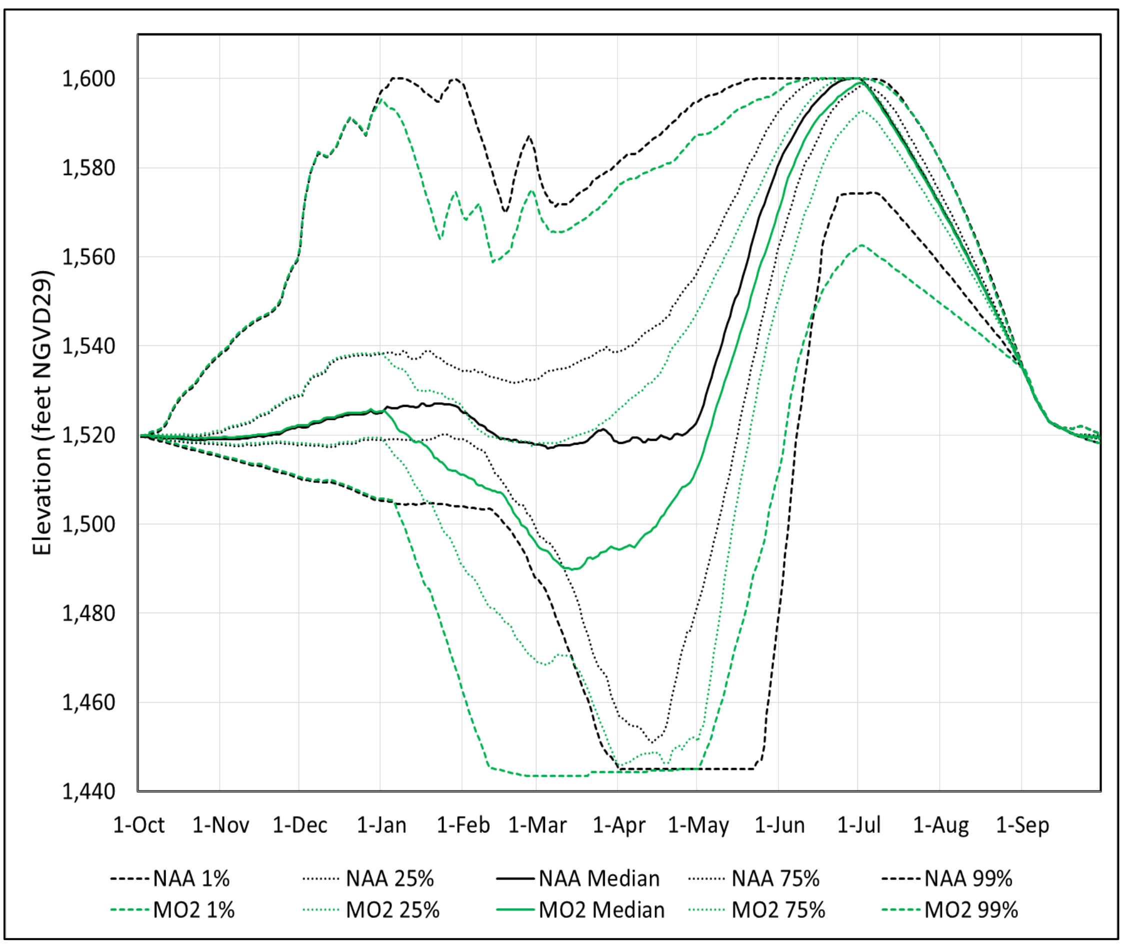



**Figure 3-56. Dworshak Reservoir Summary Hydrograph for Multiple Objective Alternative 2**

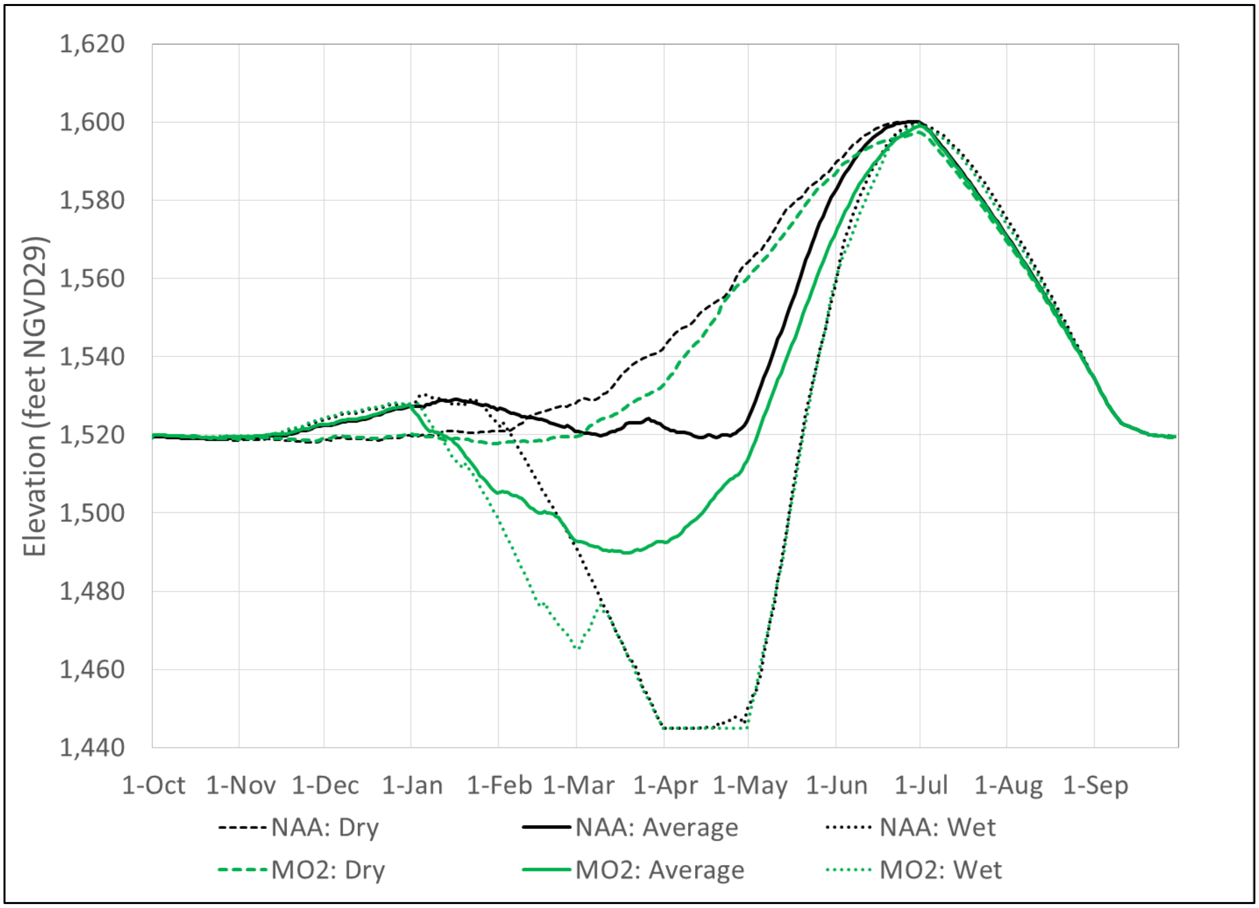



**Figure 3-57. Dworshak Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 2**

**Dworshak Dam Outflow**

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

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

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

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

- In February, outflows would increase for all but the highest flows. The median value of the monthly average outflow would increase by 2.0 kcfs.
- In March, outflows would decrease. The median value of the monthly average outflow would decrease by 1.5 kcfs.
- The outflow in April would decrease. The median value of the monthly average outflow would decrease by 1.9 kcfs.
- In May, outflows would increase for all but the highest flows. The median value of the monthly average outflow would increase by 1.0 kcfs.
- In June, outflows would decrease for all but the highest flows. The median value of the monthly average outflow would decrease by 2.2 kcfs.
- In July, outflows would decrease. The median value of the monthly average outflow would decrease by 0.2 kcfs.
- In August, the median value of the monthly average outflow would decrease by 0.4 kcfs. The lowest outflows (at the 99 percent exceedance level) would decrease by 3.2 kcfs.

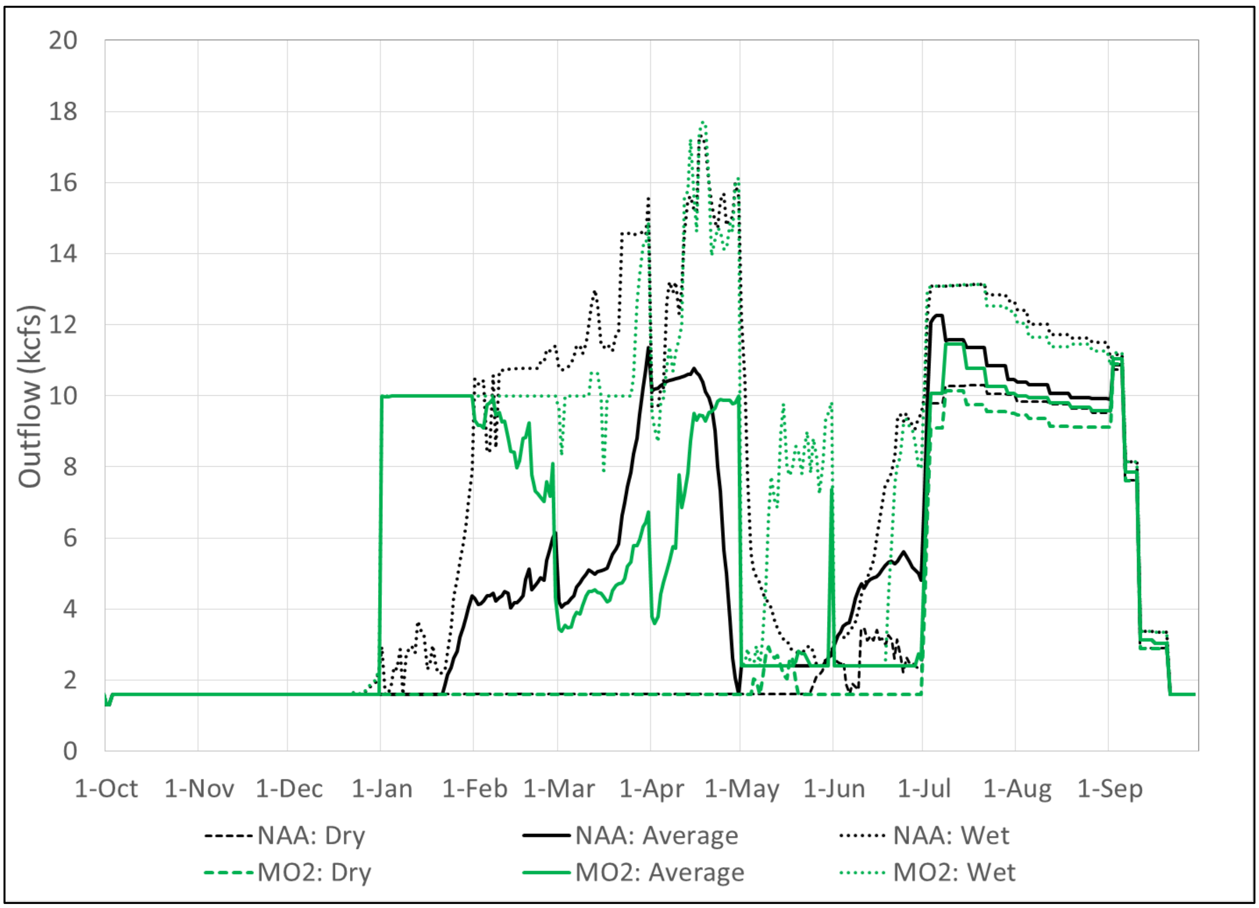



**Figure 3-58. Dworshak Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2**

**Table 3-26. Dworshak Dam Monthly Average Outflow for Multiple Objective Alternative 2 (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% | 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 | 7.4 | 9.3 | 4.5 |
| 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% |

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

### Lower Snake River Reservoir Elevations

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

- Lower Granite Dam would use the normal operating range of 733.0 to 738.0 feet NGVD29 year-round. This is a 4.0-foot elevation range increase and a 4.0-foot increase in the upper elevation from April through August compared to the No Action Alternative.
- Little Goose Dam would use the normal operating range of 633.0 to 638.0 feet NGVD29 year round. This is a 4.0-foot elevation range increase and a 4.0-foot increase in the upper elevation from April through August compared to the No Action Alternative.
- Lower Monumental Dam would use the normal operating range of 537.0 to 540.0 feet NGVD29 year round. This is a 2.0-foot elevation range increase and a 2.0-foot increase in the upper elevation from April through August compared to the No Action Alternative.
- Ice Harbor Dam would use the normal operating range of 437.0 to 440.0 feet NGVD29 year round. This is a 2.0-foot elevation range increase and a 2.0-foot increase in the upper elevation from April through August compared to the No Action Alternative.

### Clearwater River below Dworshak Dam and the Lower Snake River

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

**Table 3-27. Lower Snake Basin Monthly Average Flows for Multiple Objective Alternative 2 (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 | 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% |

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

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

### Lower Columbia River Reservoir Elevations

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

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

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

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

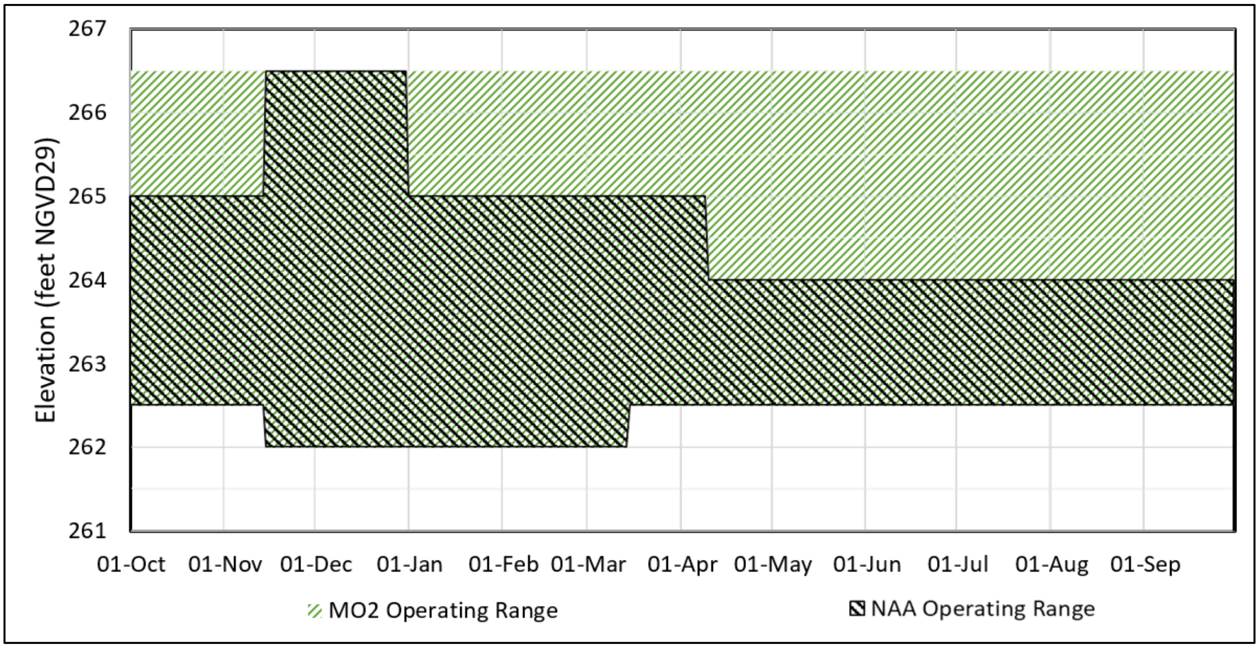



**Figure 3-59. John Day Dam Operating Range for Multiple Objective Alternative 2**

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

**Lower Columbia River Flows**

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

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

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

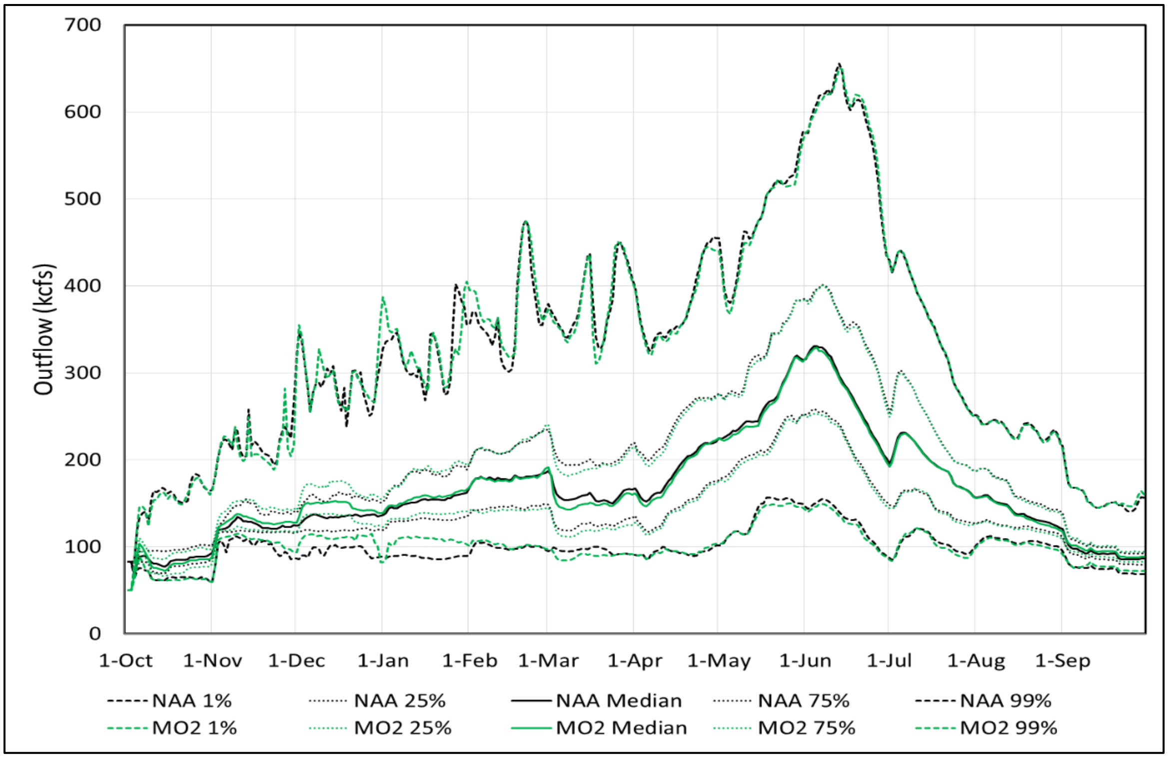



**Figure 3-60. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 2**

Conclusions from this comparison are below:

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

Finally, median hydrographs for McNary Dam outflow in dry, average, and wet years are shown in Figure 3-61. The figure provides another way to picture the effects described above, this time categorized by water year type. Higher outflows would occur in November and December for all water year types. In January, the dry and average years would continue to have higher outflows. In March outflows would decrease for all water year types.

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

**Table 3-28. McNary Dam Monthly Average Outflow for Multiple Objective Alternative 2 (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% | 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% |

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

**Table 3-29. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 2 (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 |
| | 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% |

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

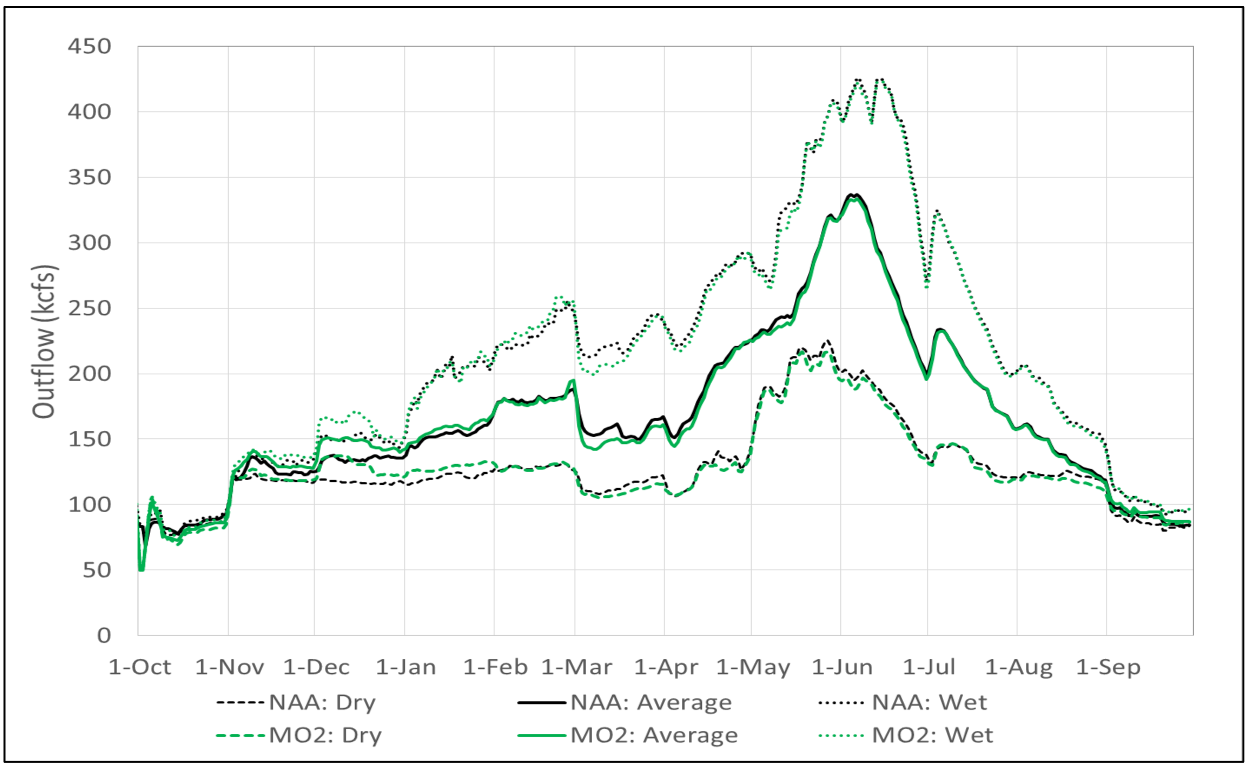



**Figure 3-61. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 2**

## SUMMARY OF EFFECTS

Under MO2, the largest changes in water levels occur at Libby, Hungry Horse, Grand Coulee, and Dworshak Dams. Lake Koocanusa water levels are substantially lower in most years from November through June, but can be higher in the drawdown period starting in January in larger forecast years, and reservoir levels are slightly higher in the later summer months. Water levels in Hungry Horse Reservoir are lower from January through June in most years, and lower pool levels in the rest of the year are less common. Lake Roosevelt water levels are lower in December through March and at the end of September. Dworshak Reservoir is drawn deeper in January, and it stays lower through July due to impacts to refill by assumptions not representing the intended operation.

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

### *3.2.4.6 Multiple Objective Alternative 3*

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

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

#### REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

#### Lake Koocanusa (Libby Dam Reservoir) Elevation

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

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

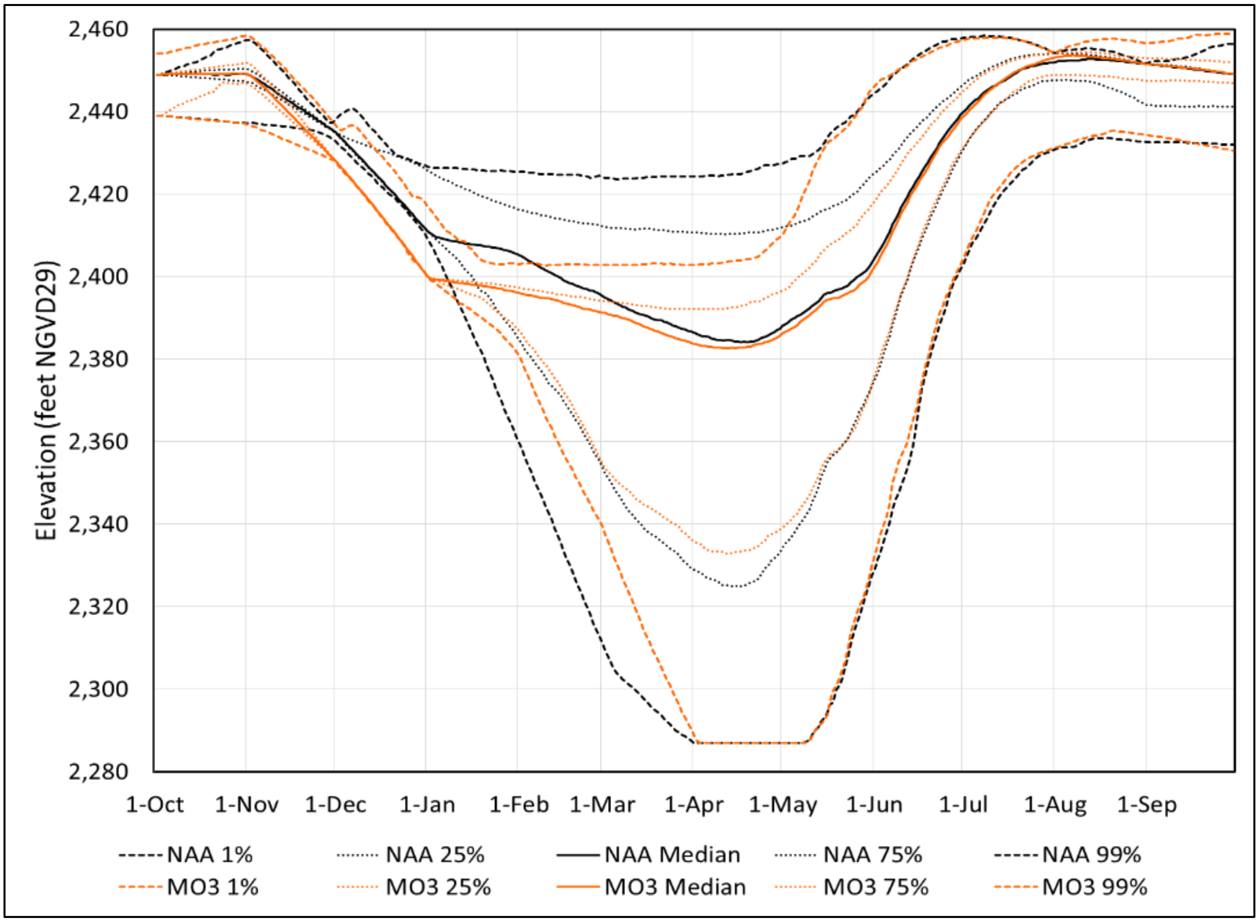



**Figure 3-62. Lake Koocanusa Summary Hydrograph for Multiple Objective Alternative 3**

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

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

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

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

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

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

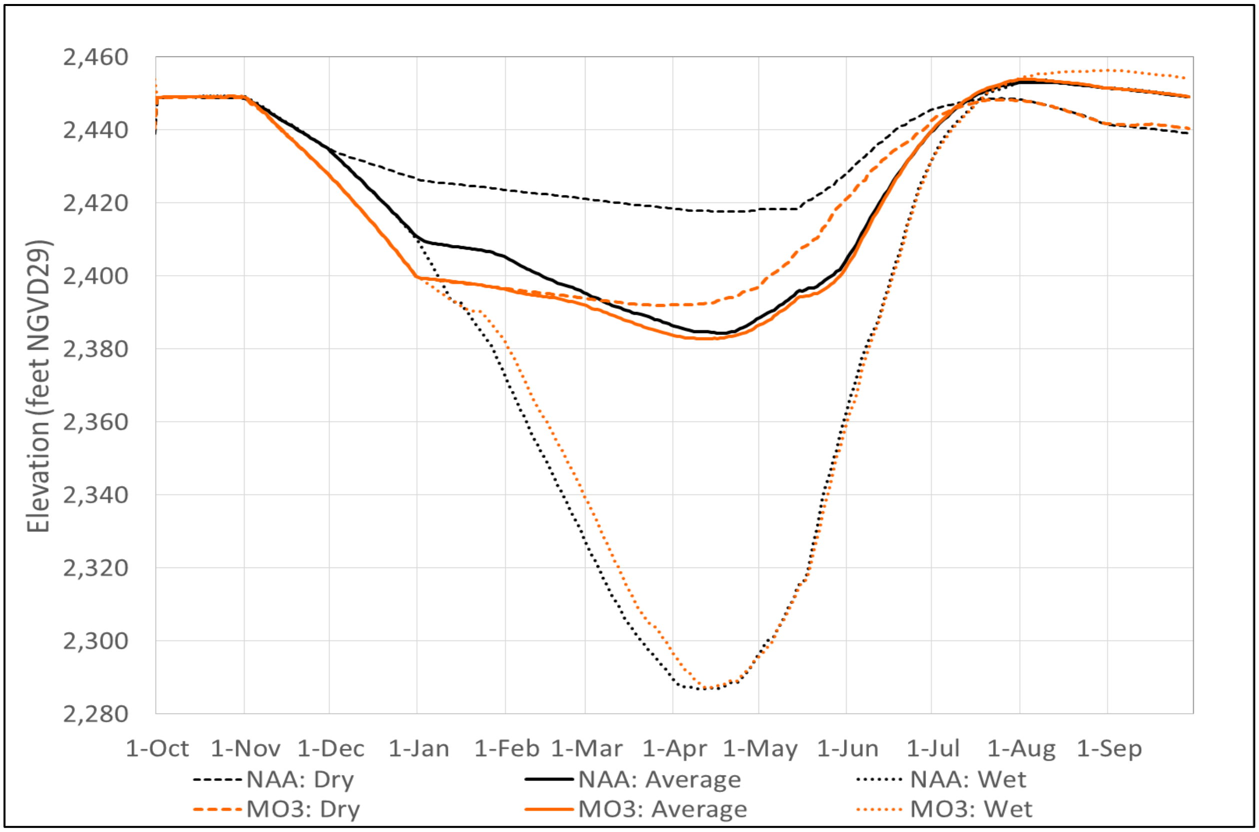



**Figure 3-63. Lake Koocanusa Water Year Type Hydrographs for Multiple Objective Alternative 3**

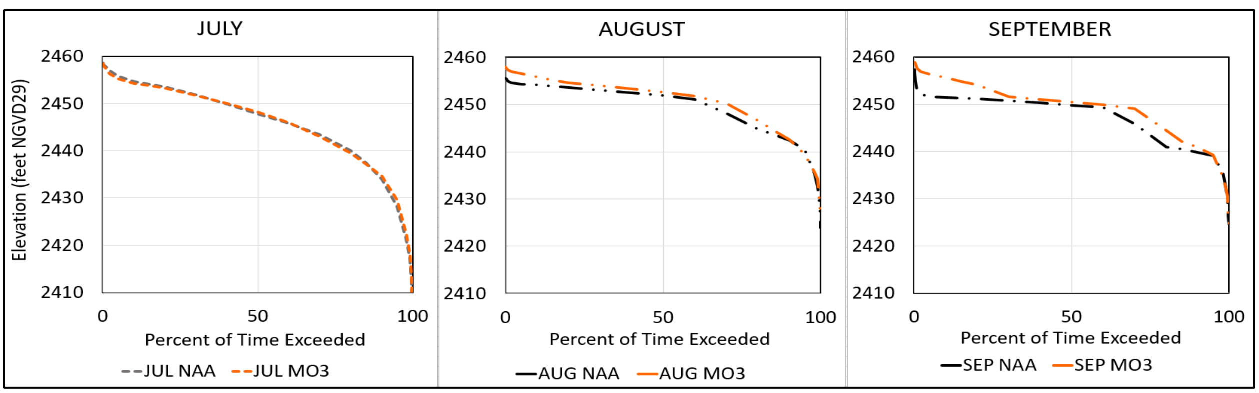



**Figure 3-64. Lake Koocanusa Summer Elevations for Multiple Objective Alternative 3**

**Libby Dam Outflow**

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

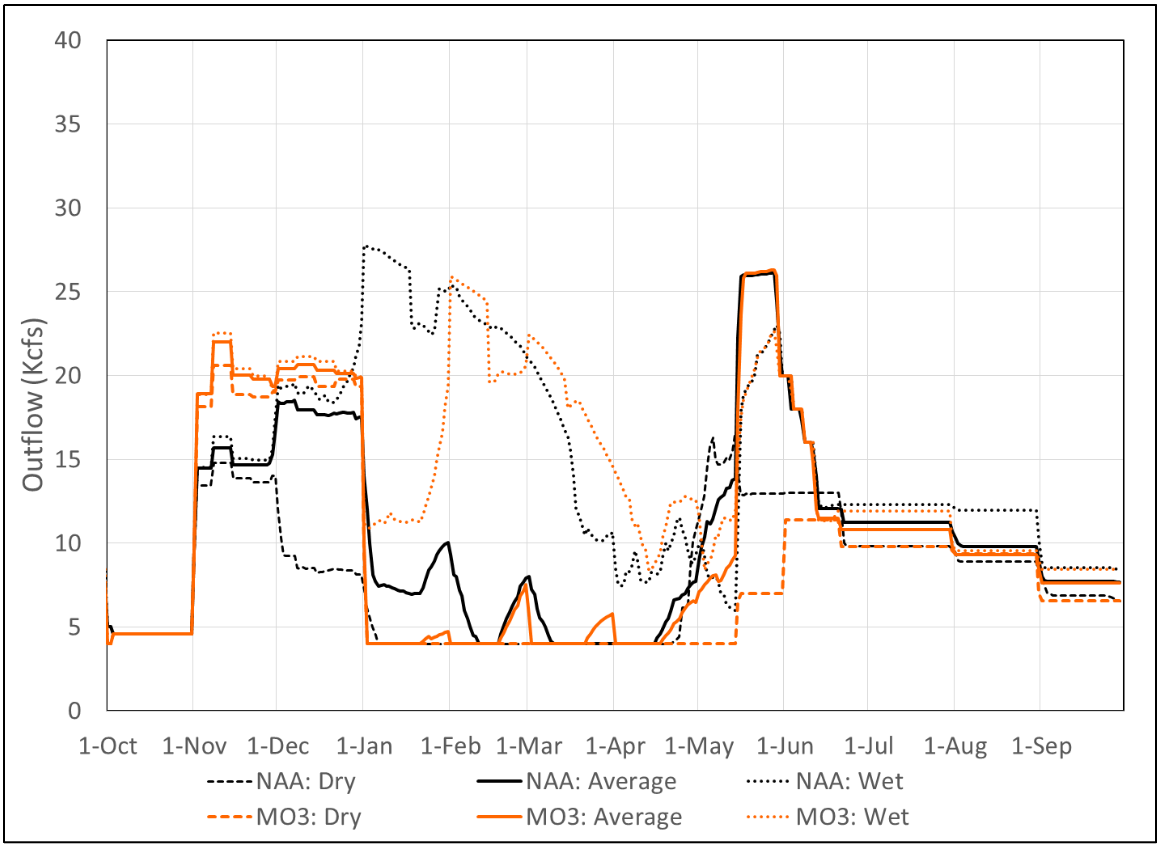



**Figure 3-65. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 3**

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

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

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

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

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

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

**Table 3-30. Libby Dam Monthly Average Outflow for Multiple Objective Alternative 3 (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% | 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% |

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

### Bonners Ferry Flow

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

**Table 3-31. Bonners Ferry Monthly Average Flow for Multiple Objective Alternative 3 (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% | 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% |

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

### Hungry Horse Reservoir Elevation

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 operations.

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

The water year would begin with the reservoir levels for MO3 being lower than those for the No Action Alternative. This is because the operations associated with the *Hungry Horse Additional Water Supply* measure would leave the reservoir at a lower elevation on September 30 than under the No Action Alternative, and the condition would carry over to the following water year. It should be noted that when MO3 was modeled, the initial Hungry Horse Reservoir levels at the start of each water year were erroneously set lower than intended. A subsequent sensitivity analysis revealed that this initialization error primarily affected results in the fall and winter. In the summary hydrograph, Figure 3-66, the median and higher elevations should have water levels 1 to 3 feet higher than shown from October through May. Below the median, the results should be 5 to 10 feet higher from October through February.

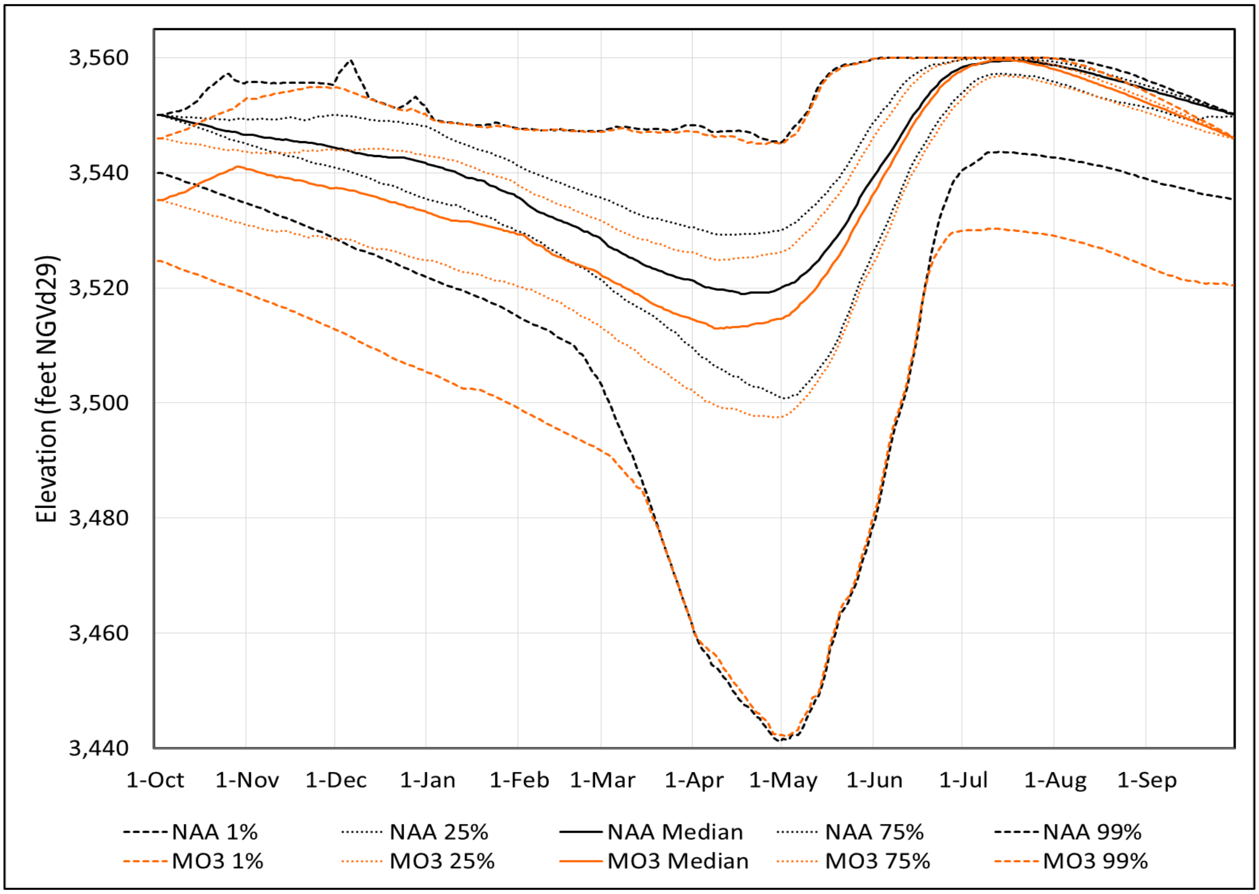



**Figure 3-66. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 3**

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

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

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

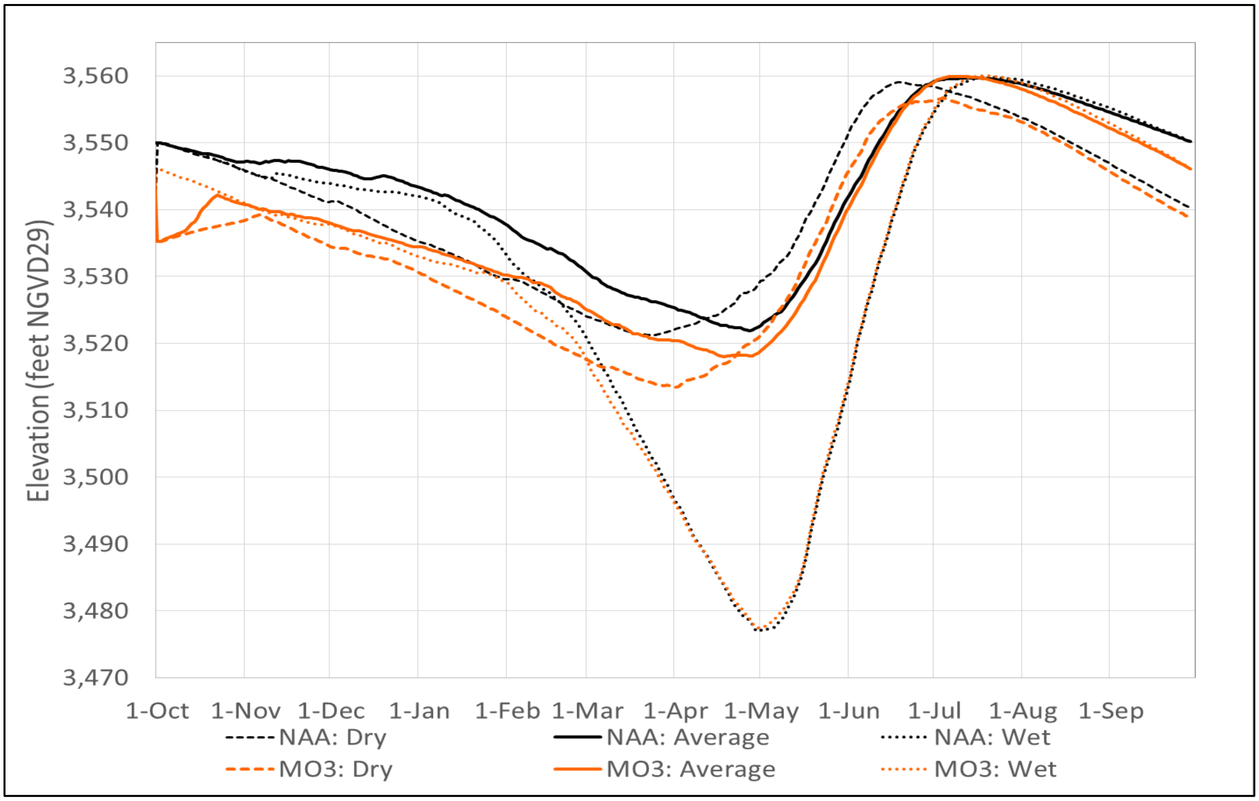



**Figure 3-67. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 3**

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

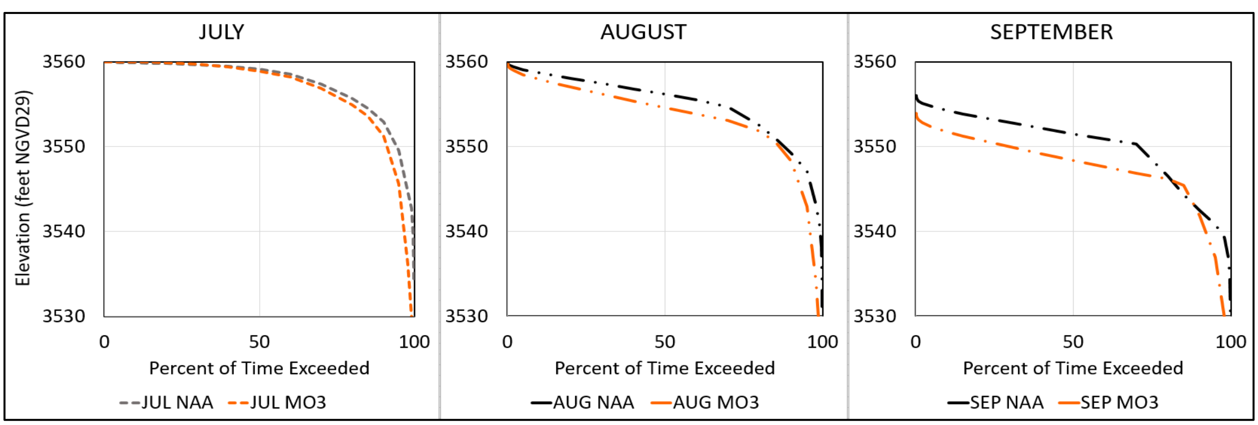



**Figure 3-68. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 3**

**Hungry Horse Dam Outflow**

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 outflows. The outflows would differ from the No Action Alternative depending on the time of year. Figure 3-69 shows median hydrographs for Hungry Horse Dam outflow in dry, average, and wet years.

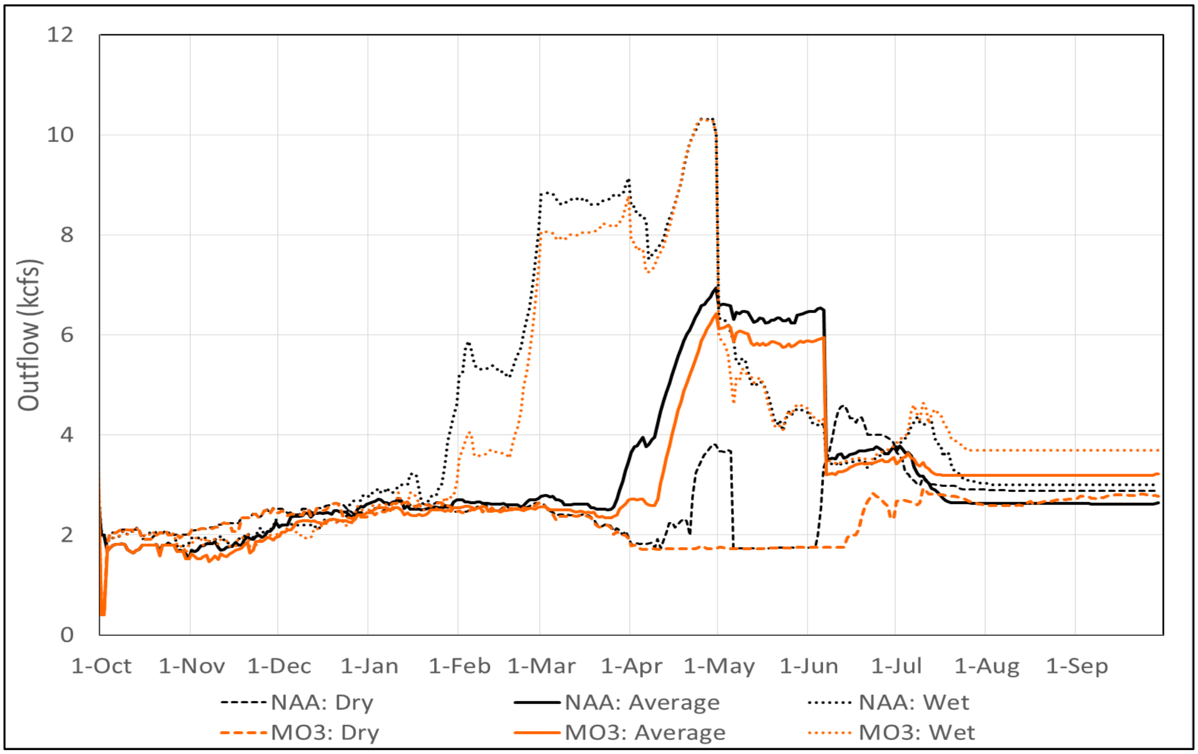



**Figure 3-69. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 3**

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

**Table 3-32. Hungry Horse Dam Monthly Average Outflow for Multiple Objective Alternative 3 (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 | 1.8 | 1.9 | 2.0 |
| 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% |

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

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

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

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

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

### Columbia Falls Flow

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

**Table 3-33. Columbia Falls Monthly Average Flow for Multiple Objective Alternative 3 (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% | 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% |

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

### Lake Pend Oreille Elevation

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

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

**Albeni Falls Outflow**

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

**Table 3-34. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 3 (as 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 | -0.1 | -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% |

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

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

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

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

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

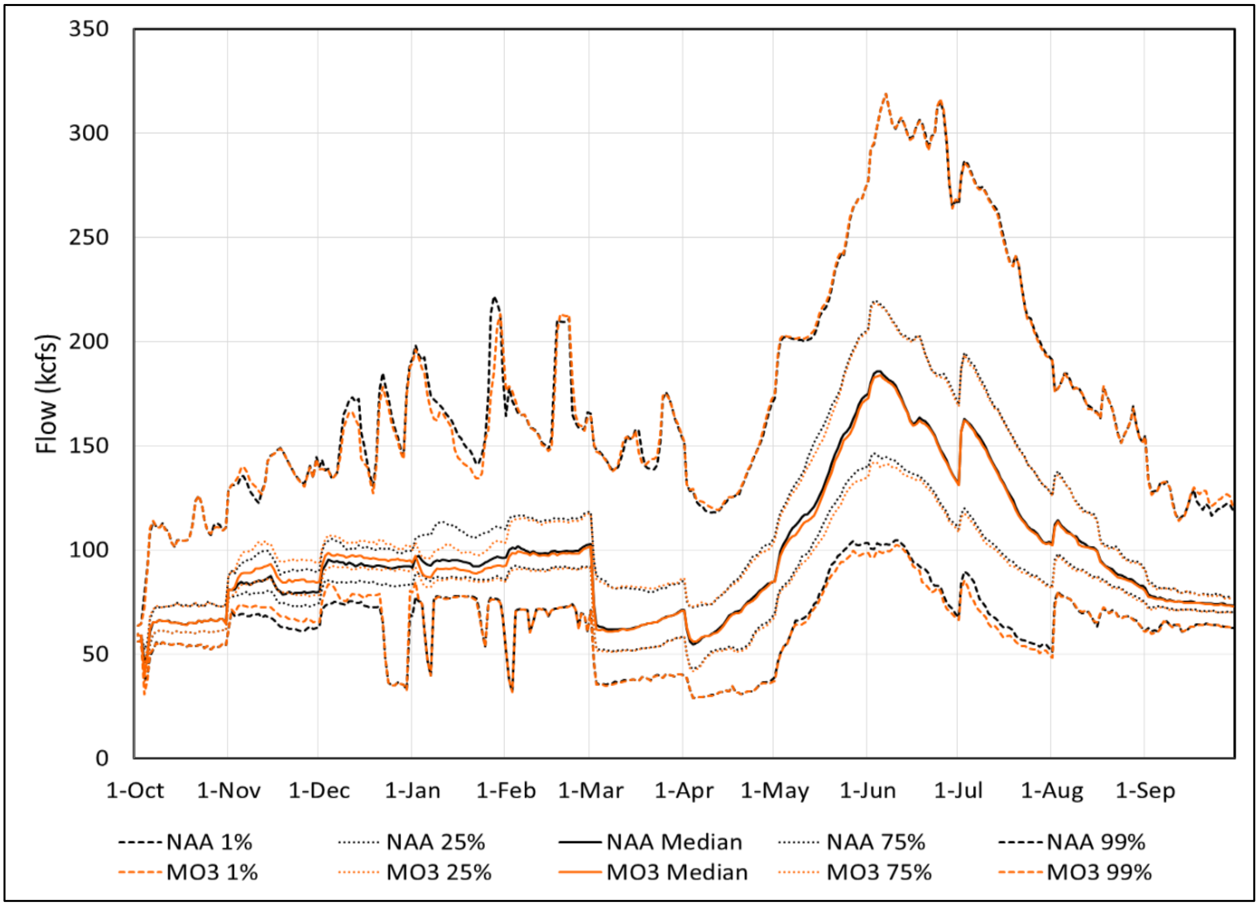



**Figure 3-70. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 3**

### Lake Roosevelt (Grand Coulee Dam Reservoir) Elevation

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

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

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

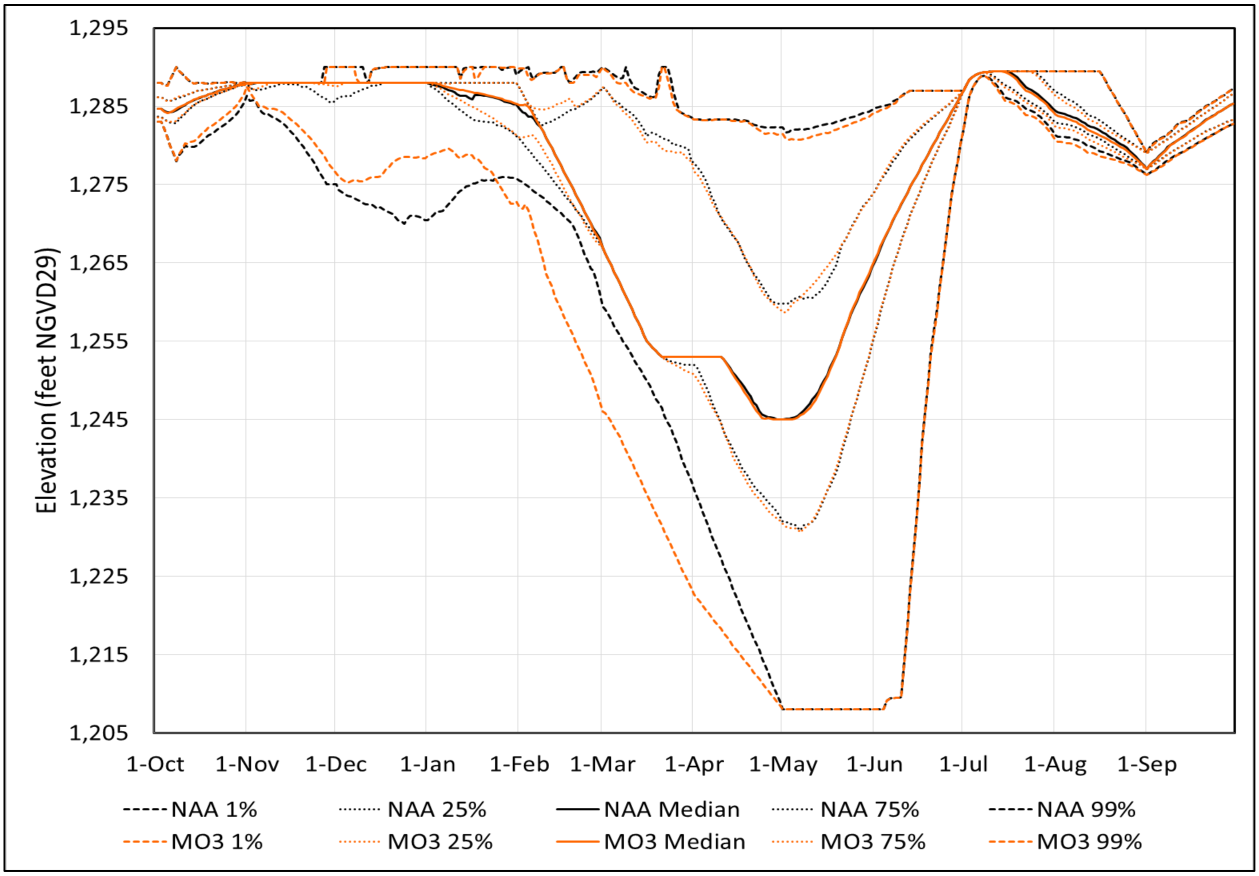



**Figure 3-71. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 3**

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

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

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

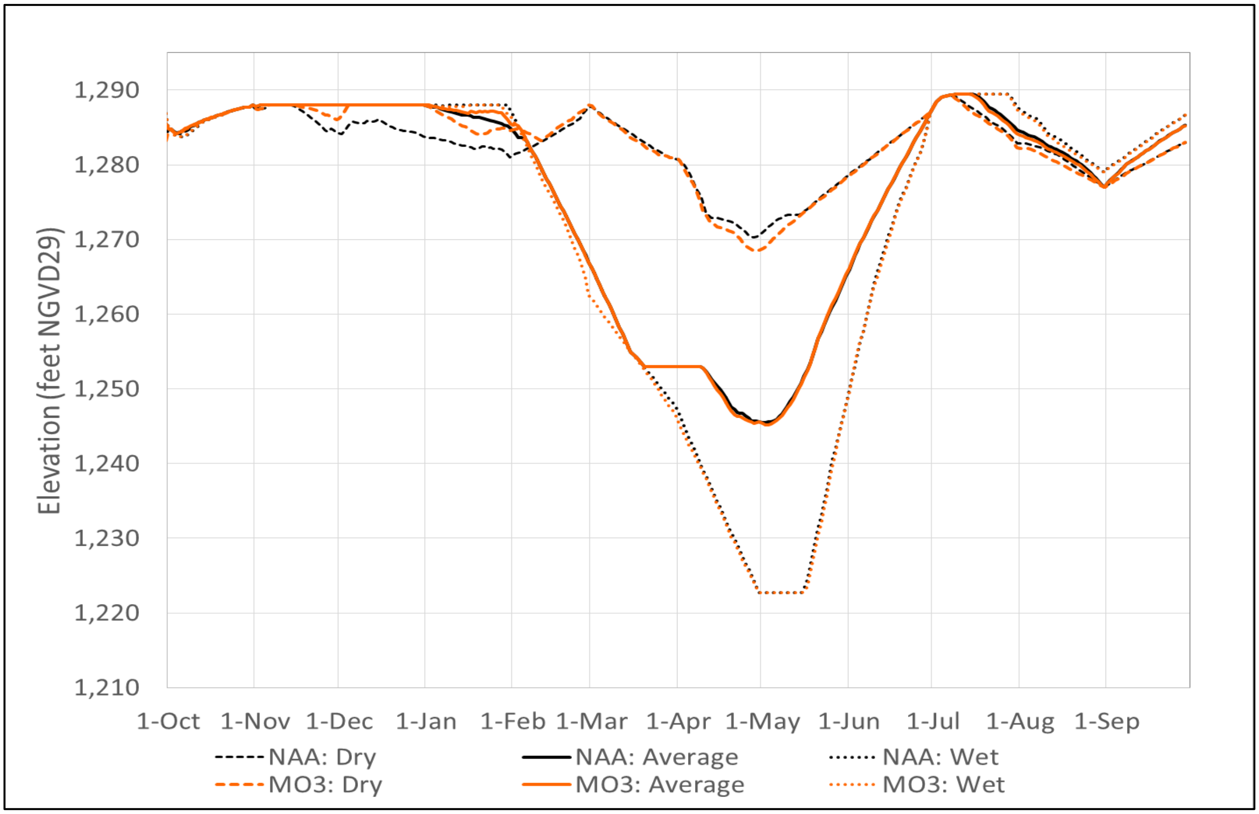



**Figure 3-72. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 3**

**Grand Coulee Dam Drum Gate Maintenance**

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

The changes in elevations for MO3 that influence the decision to conduct drum gate maintenance would not change significantly relative to the No Action Alternative (April 30 FRM elevation targets and drum gate initiation methodology is discussed in more detail in Part 1 of Appendix B). The decision to conduct drum gate maintenance is based on the February water supply forecast and the resulting April 30 FRM elevation projection (April 30 FRM elevation target at or below 1,255 or 1,265 feet NGVD29 depending on how recently the maintenance has been conducted). This is not to say the spring elevations are the same for the two alternatives but rather there are a similar number of years that elevations would allow for drum gate maintenance. In both MO3 and the No Action Alternative, drum gate maintenance would be achievable in 65 percent of the years.

**Grand Coulee Dam Outflow**

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

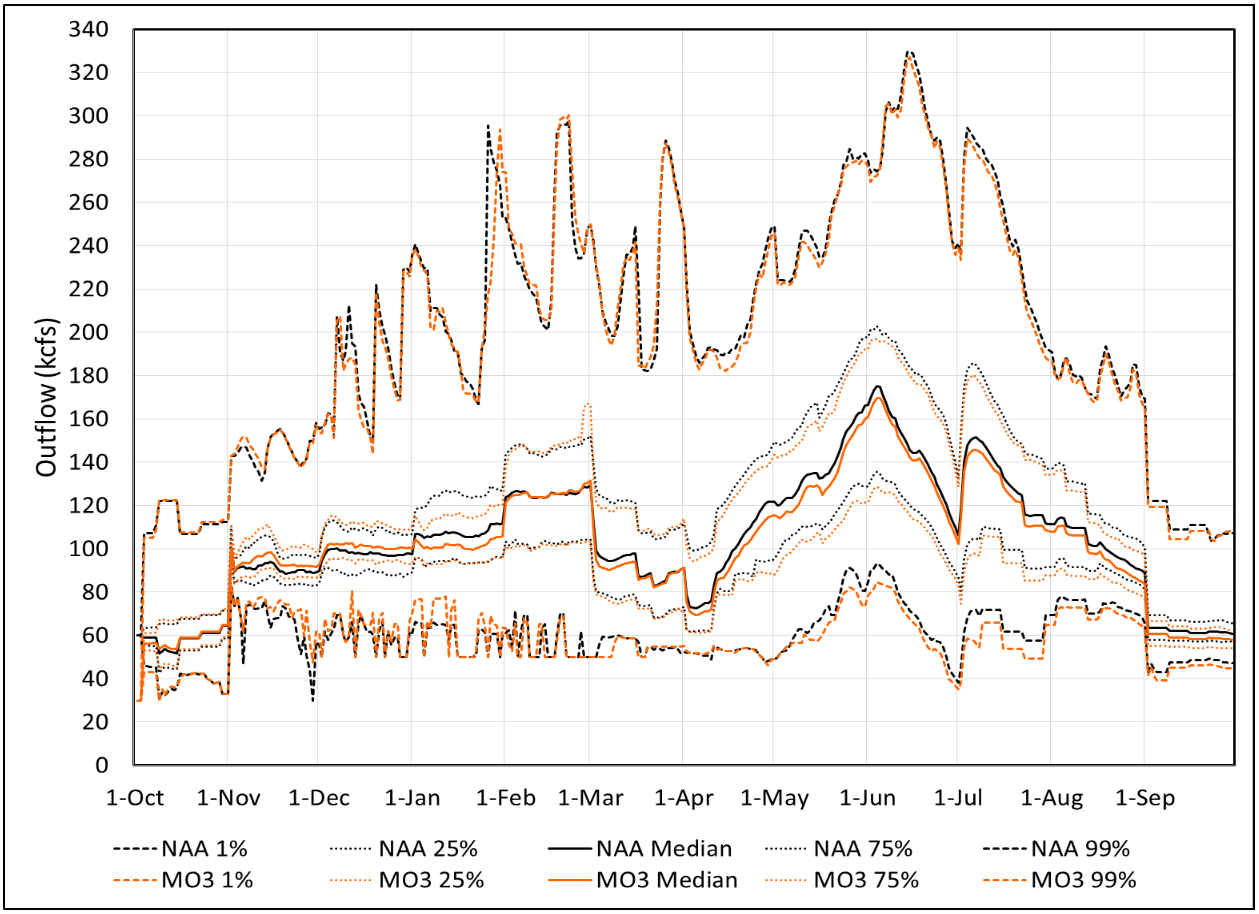



**Figure 3-73. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 3**

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

**Table 3-35. Grand Coulee Dam Monthly Average Outflow for Multiple Objective Alternative 3 (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% |

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

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

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

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

- In April the volume of water to be pumped from Lake Roosevelt into Banks Lake as a result of the *Lake Roosevelt Additional Water Supply* measure would increase. The April through September period would have the greatest total pumping volumes, as well as the greatest additional pumping volumes as called for in the *Lake Roosevelt Additional Water Supply* measure.
- In April, May, and June, the monthly average outflows would consistently be lower. At the median level, they would decrease by 4.8, 6.7, and 4.8 kcfs, respectively. These changes are largely due to the *Lake Roosevelt Additional Water Supply* measure and changes to inflows from projects upstream (Libby and Hungry Horse Dams), though other measures also have an influence. In April, May and June the measure *Lake Roosevelt Additional Water Supply* would reduce flows approximately 3.2, 3.2, and 3.0 kcfs respectively.
- In July, August, and September, monthly average outflows would also be consistently lower. At the median level, the monthly average outflow for July, August, and September would be reduced by 4.6, 3.9, and 3.2 kcfs, respectively. These changes are predominantly due to the *Lake Roosevelt Additional Water Supply* measure. The *Lake Roosevelt Additional Water Supply* measure would decrease flows by 4.2, 2.6, and 2.5 kcfs in July, August, and September respectively.
- The *Grand Coulee Maintenance Operations* measure would not impact reservoir elevations or total outflows, but would reduce the hydraulic capacity through the power plants, resulting in additional spill and an increase in TDG in some situations.

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

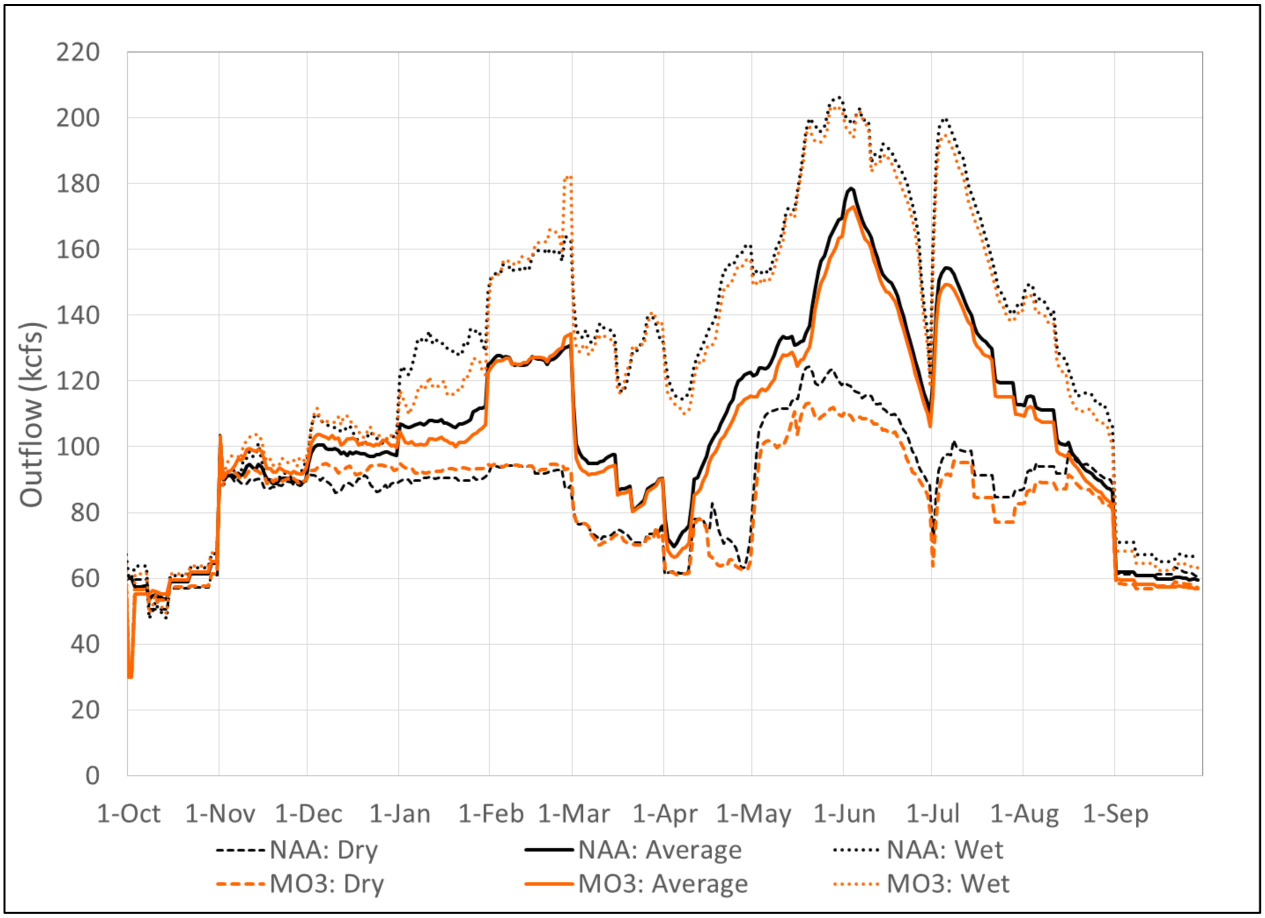



**Figure 3-74. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 3**

**Middle Columbia River below Grand Coulee Dam**

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

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

**Table 3-36. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative 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% |

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

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Dworshak Dam

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

### Clearwater and Snake Rivers below Dworshak Dam

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

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

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

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

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

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

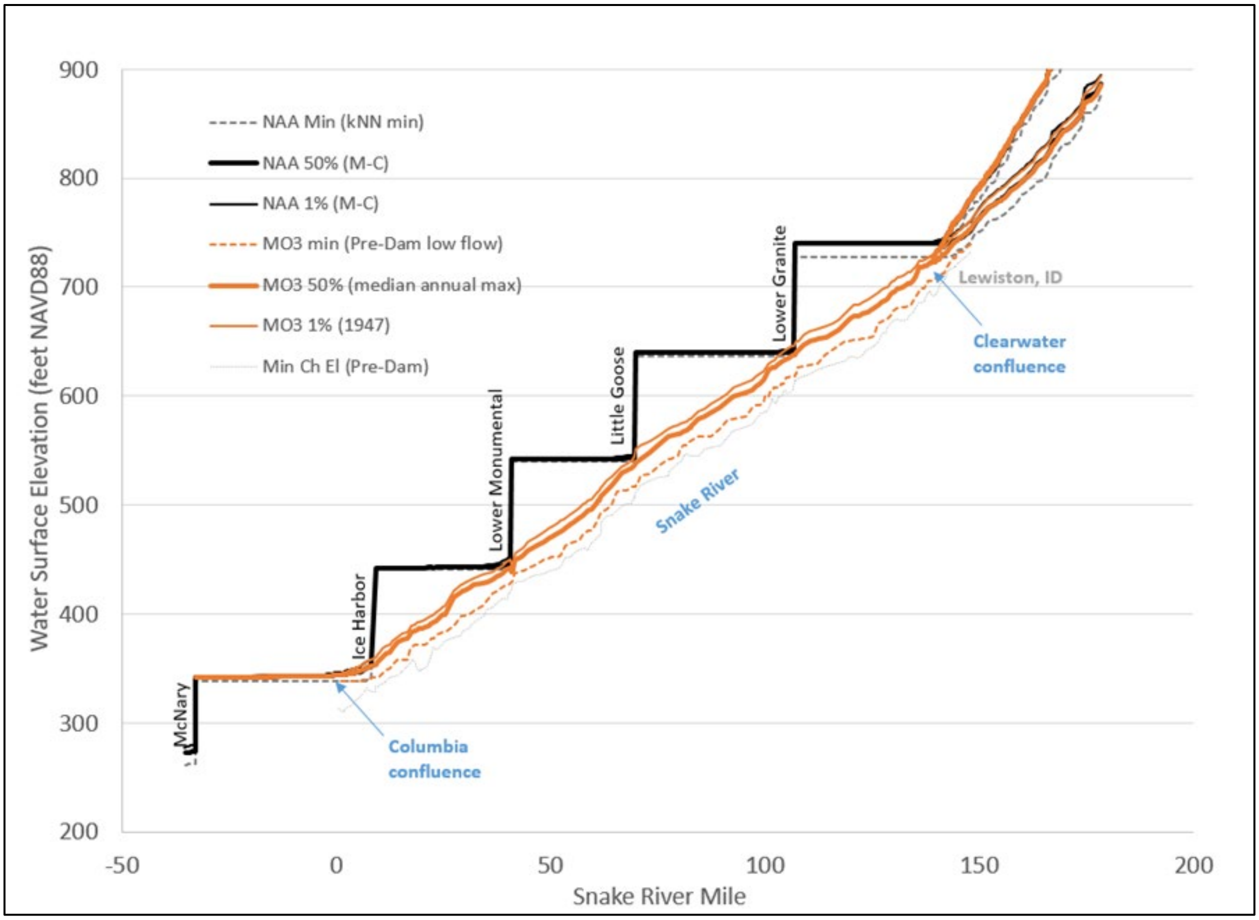



**Figure 3-75. Lower Snake River Water Surface Profiles for Multiple Objective Alternative 3**

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

### Lower Columbia River Reservoir Elevations

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

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

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

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

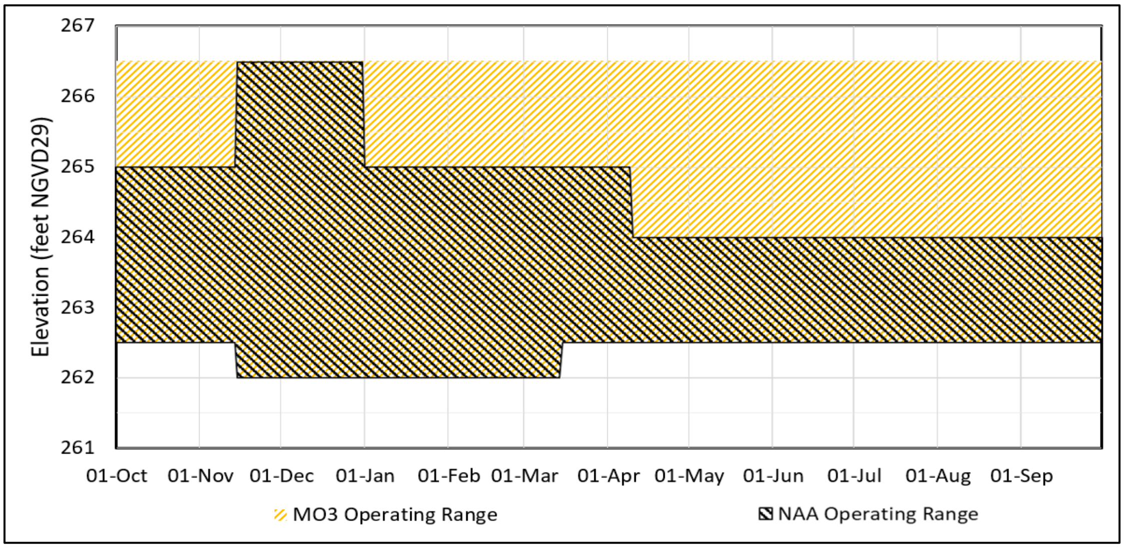



**Figure 3-76. John Day Dam Operating Range for Multiple Objective Alternative 3**

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

**Lower Columbia River Flows**

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

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

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

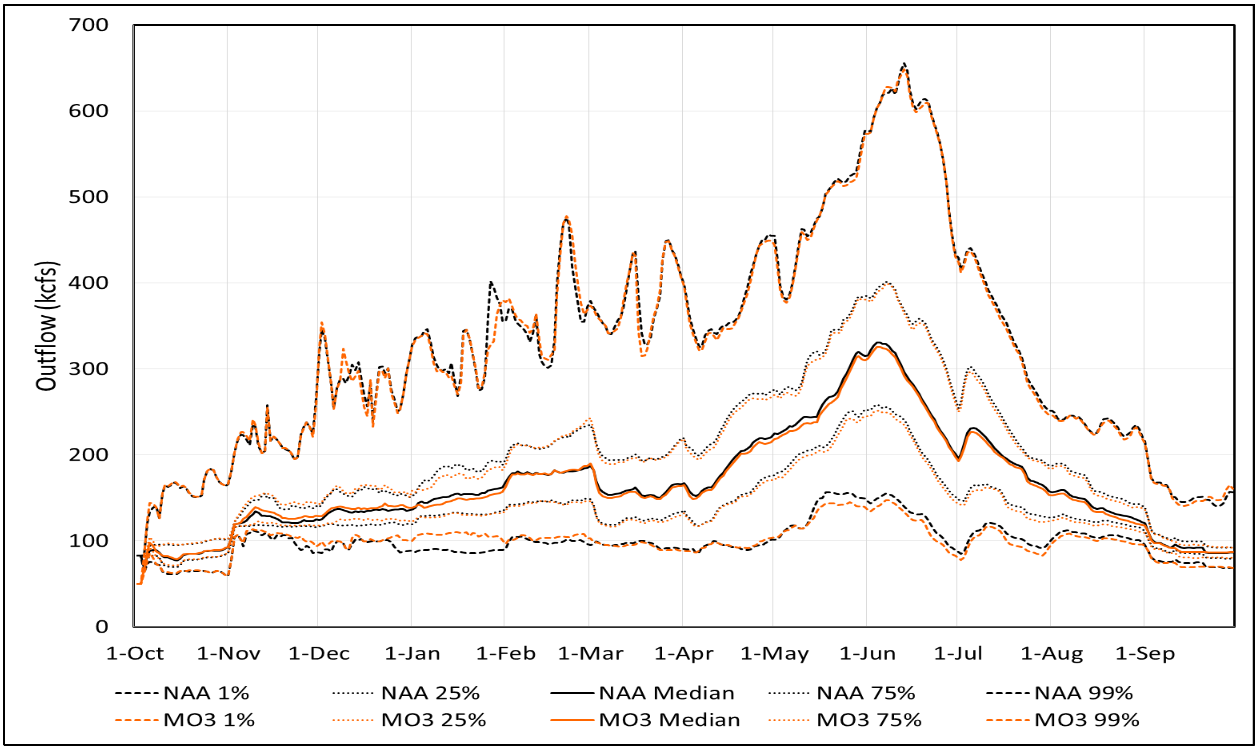



**Figure 3-77. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 3**

Conclusions from this comparison are as follows:

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

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

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

**Table 3-37. McNary Dam Monthly Average Outflow for Multiple Objective Alternative 3 (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% | 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 (kcfs) | 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% |

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

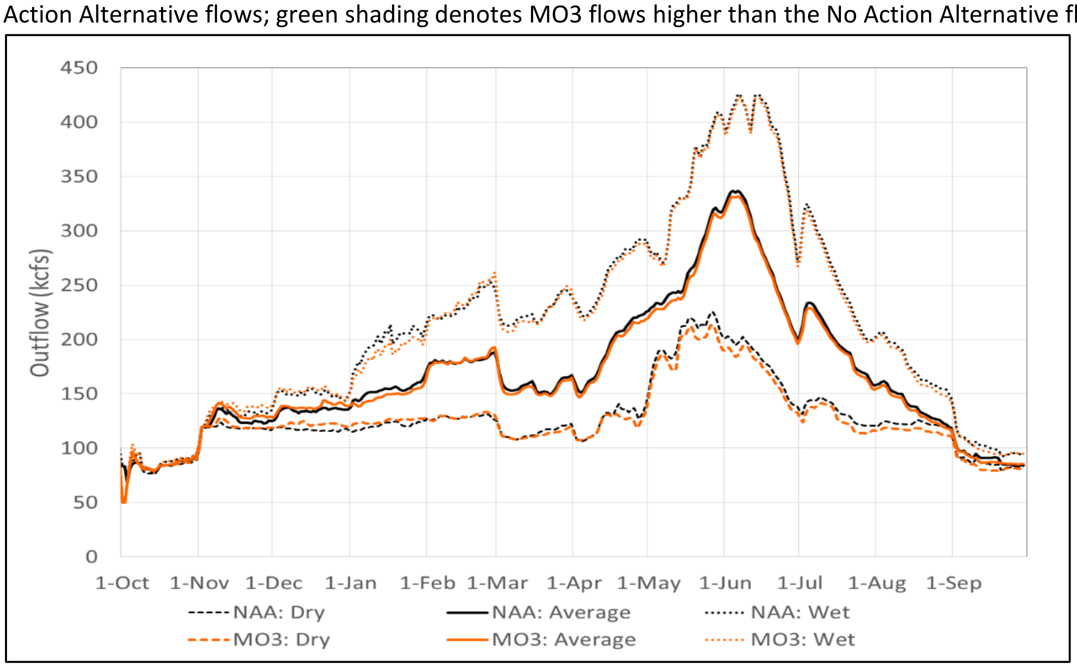



**Figure 3-78. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 3**

**Table 3-38. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 3 (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% |

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

**SUMMARY OF EFFECTS**

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

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

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

### *3.2.4.7 Multiple Objective Alternative 4*

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

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

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

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

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

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

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

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

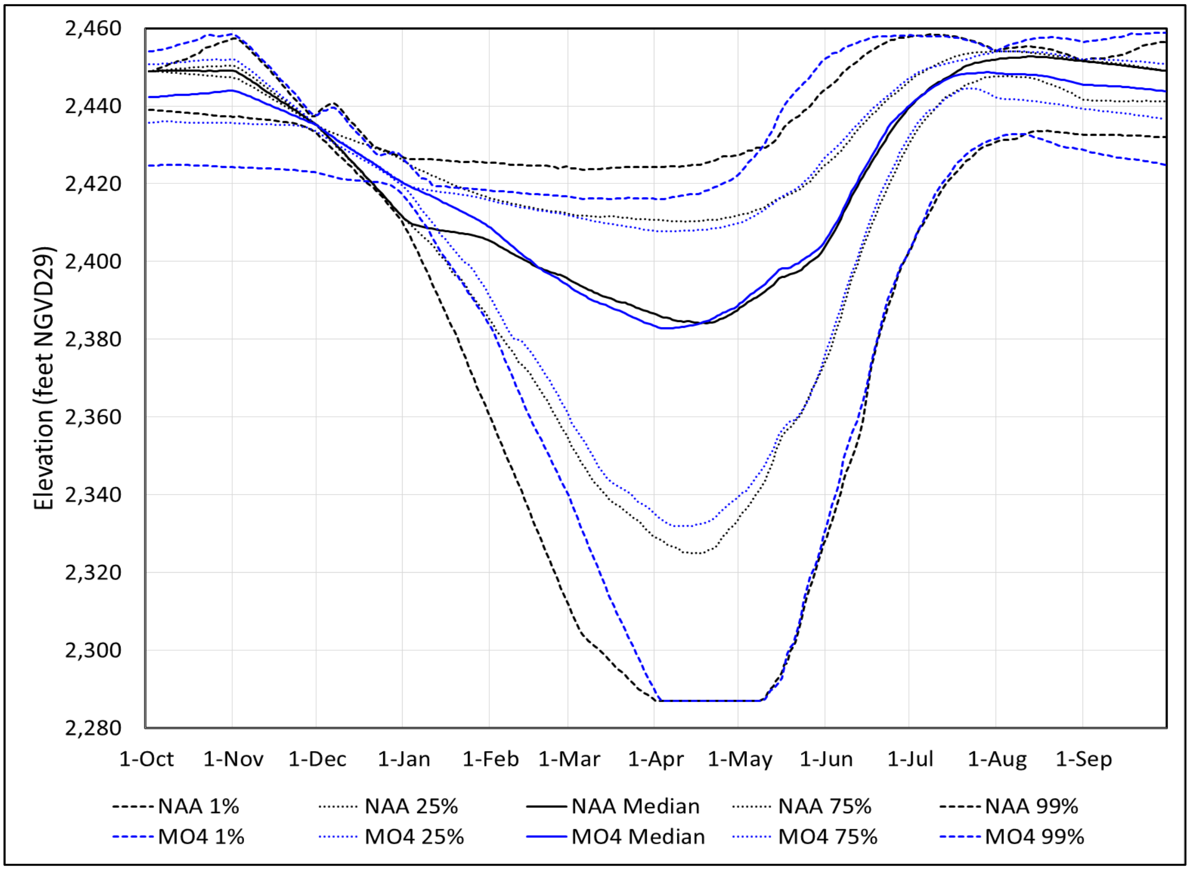



**Figure 3-79. Lake Koocanusa Summary Hydrograph for Multiple Objective Alternative 4**

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

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

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

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

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

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

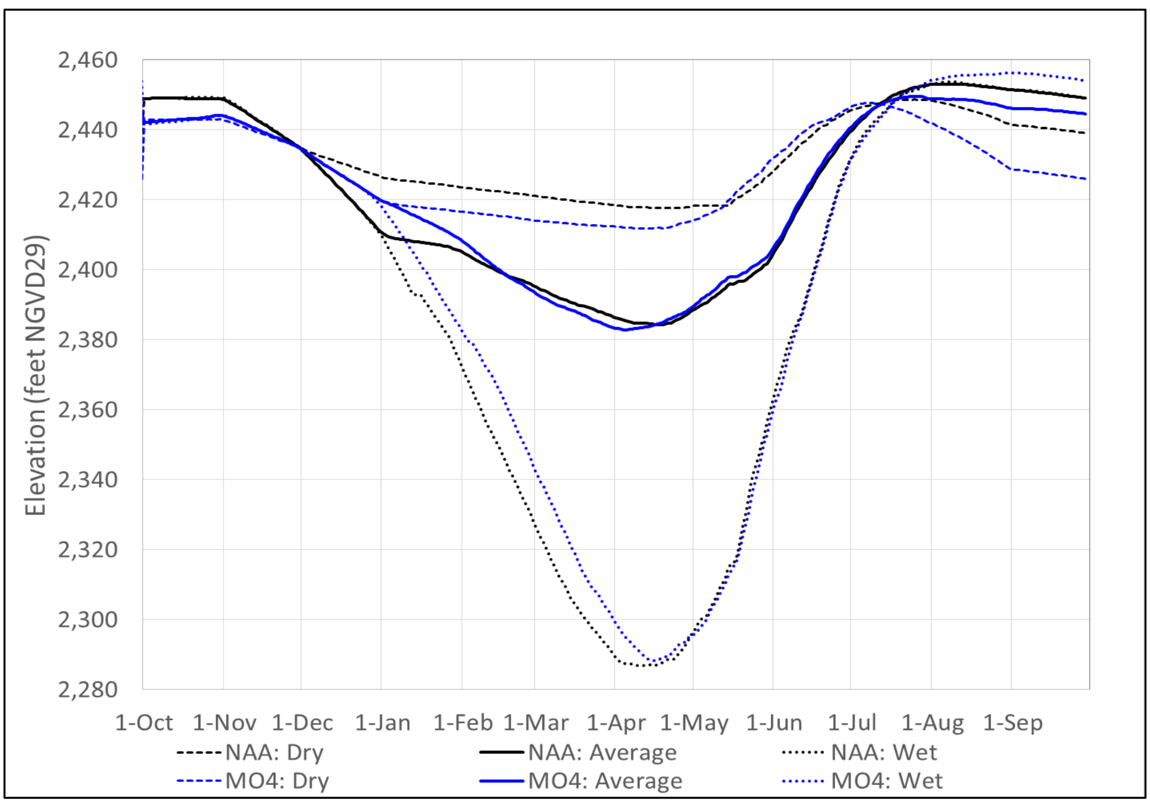



**Figure 3-80. Lake Koocanusa Water Year Type Hydrographs for Multiple Objective Alternative 4**

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

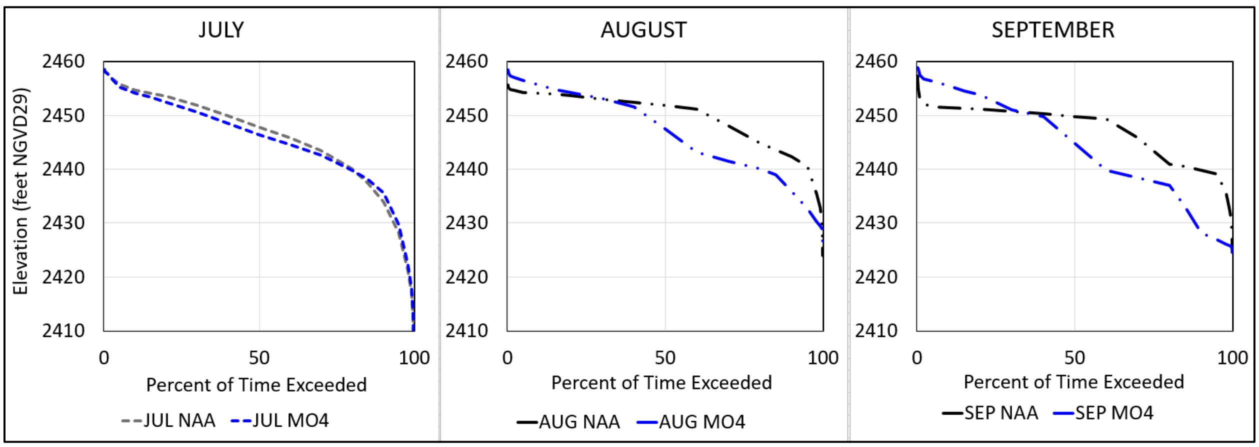



**Figure 3-81. Lake Koocanusa Summer Elevations for Multiple Objective Alternative 4**

### Libby Dam Outflow

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

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

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

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

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

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

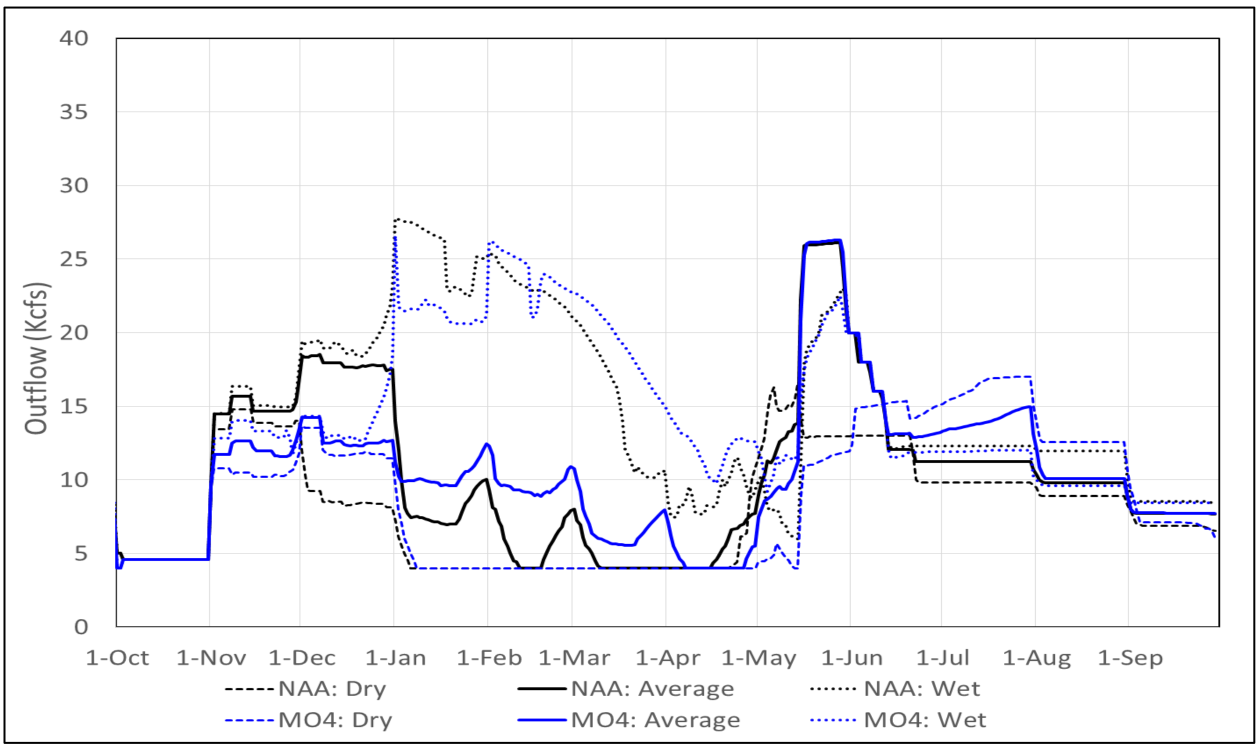



**Figure 3-82. Libby Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4**

**Table 3-39. Libby 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% | 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% |

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.

### Kootenai River below Libby Dam

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

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

**Table 3-40. Bonners Ferry Monthly Average Flow 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% | 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% |

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.

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

| | Changes in Median Monthly River Stage (feet) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kootenai River Location | 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 |

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

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

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

**Table 3-42. Percentage of Days Kootenai River Stage Would be Above 1,753 feet NGVD29 at 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% |

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

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

**Hungry Horse Reservoir Elevation**

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

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

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

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

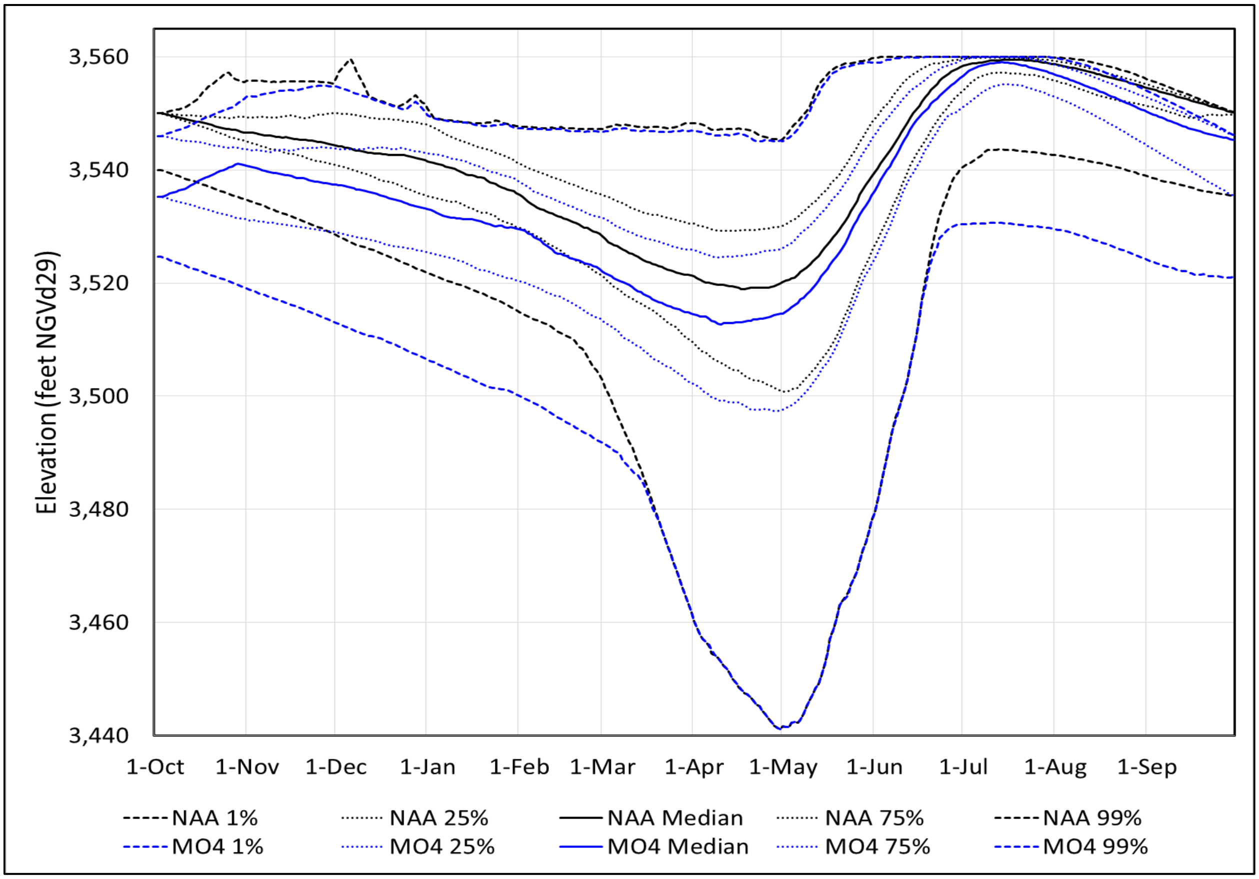



**Figure 3-83. Hungry Horse Reservoir Summary Hydrograph for Multiple Objective Alternative 4**

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

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

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

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

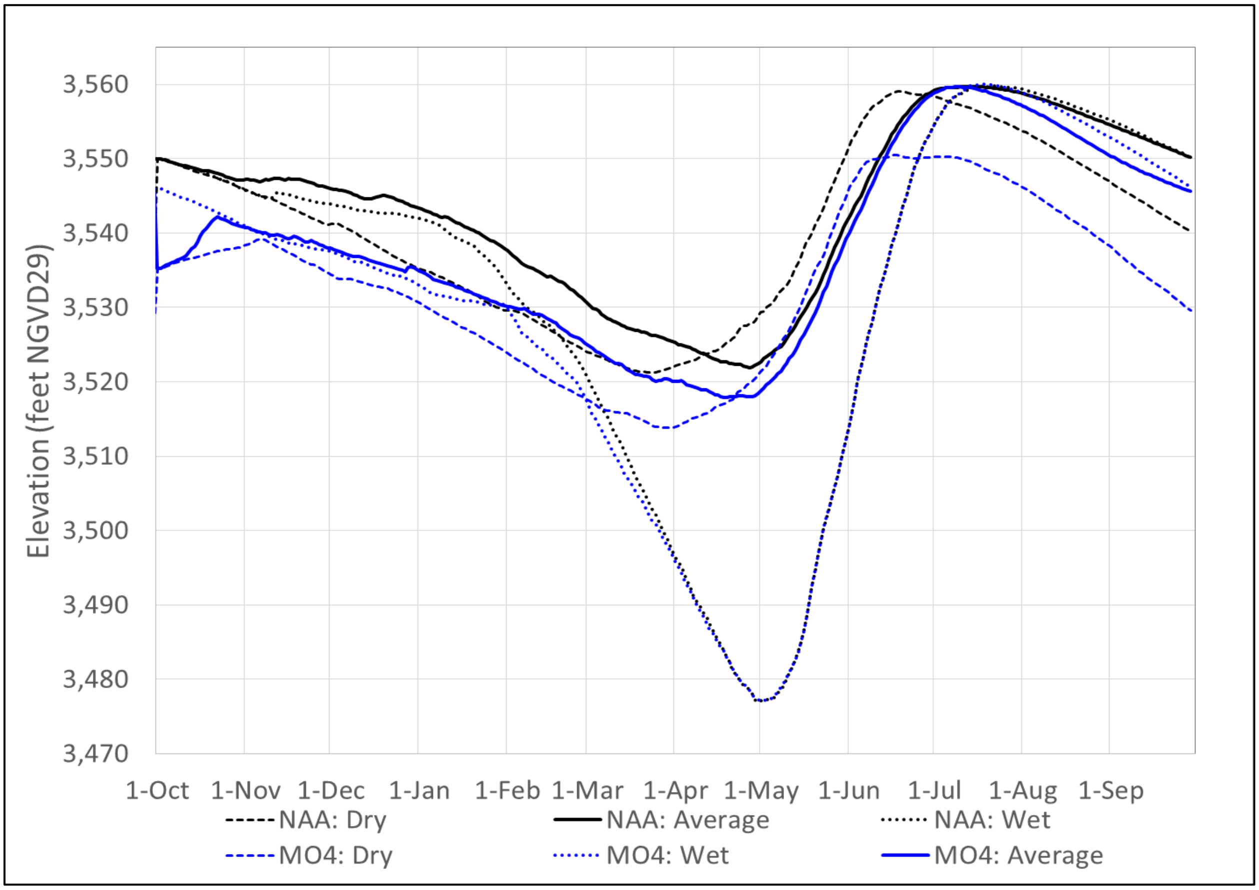



**Figure 3-84. Hungry Horse Reservoir Water Year Type Hydrographs for Multiple Objective Alternative 4**

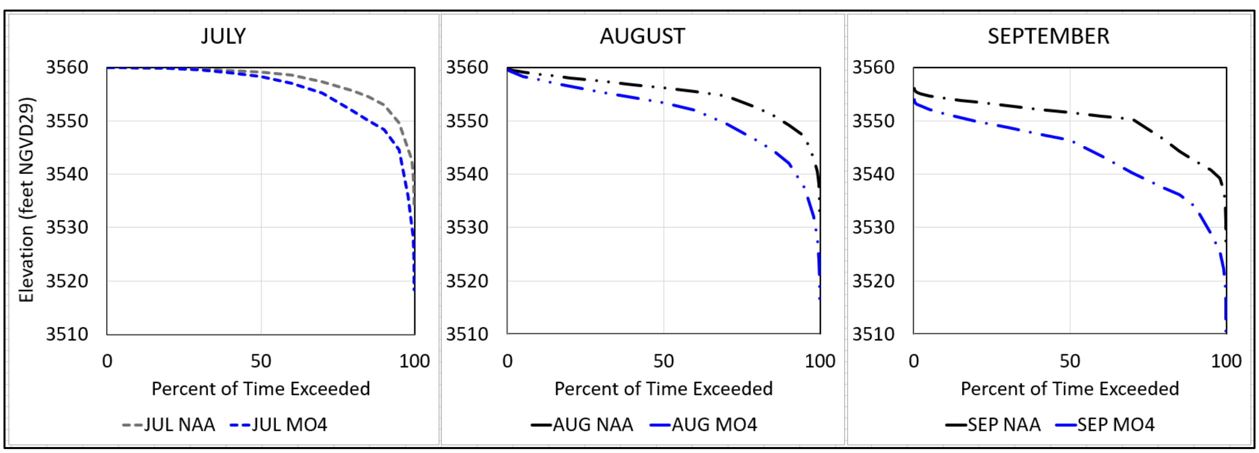



**Figure 3-85. Hungry Horse Reservoir Summer Elevations for Multiple Objective Alternative 4**

**Hungry Horse Dam Outflow**

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

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

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

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

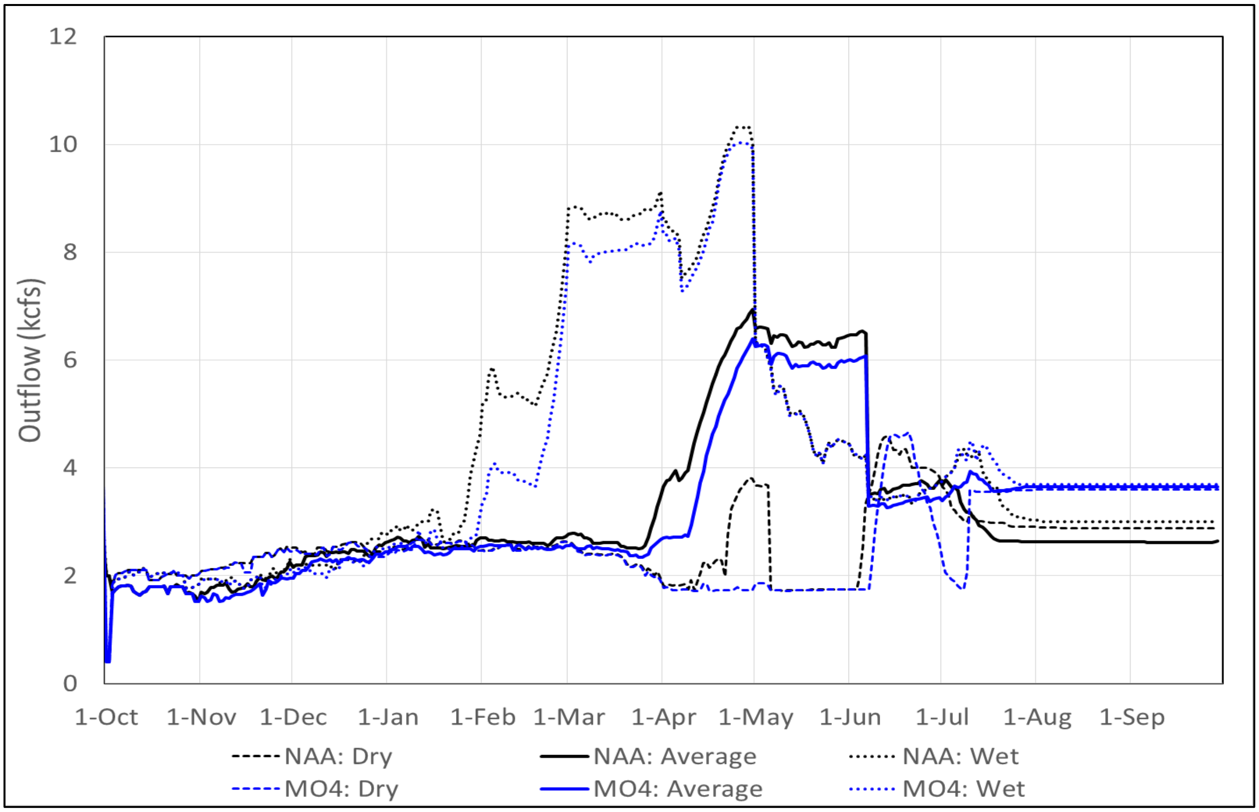



**Figure 3-86. Hungry Horse Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4**

**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 | 1.8 | 1.9 | 2.0 |
| 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% |

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.

### Columbia Falls Flow

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

**Table 3-44. Columbia Falls Monthly Average Flow 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% | 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% |

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.

### Lake Pend Oreille Elevation

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

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

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

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

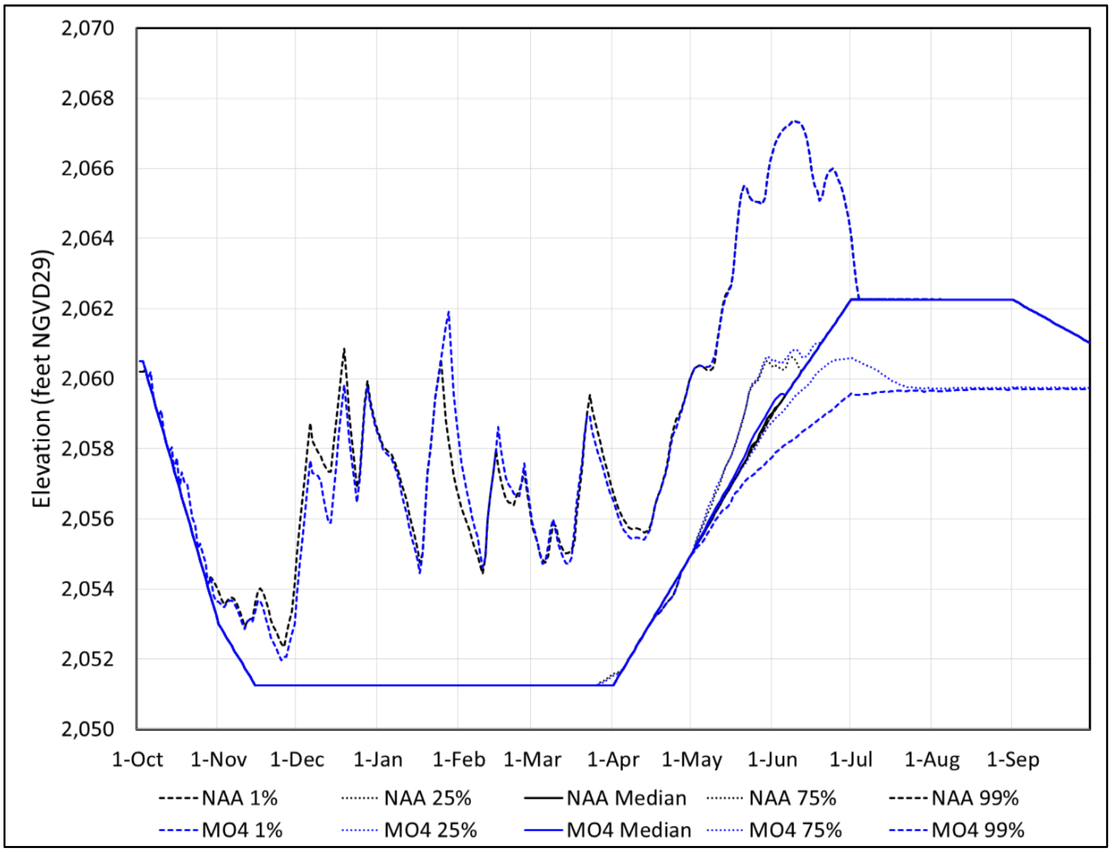
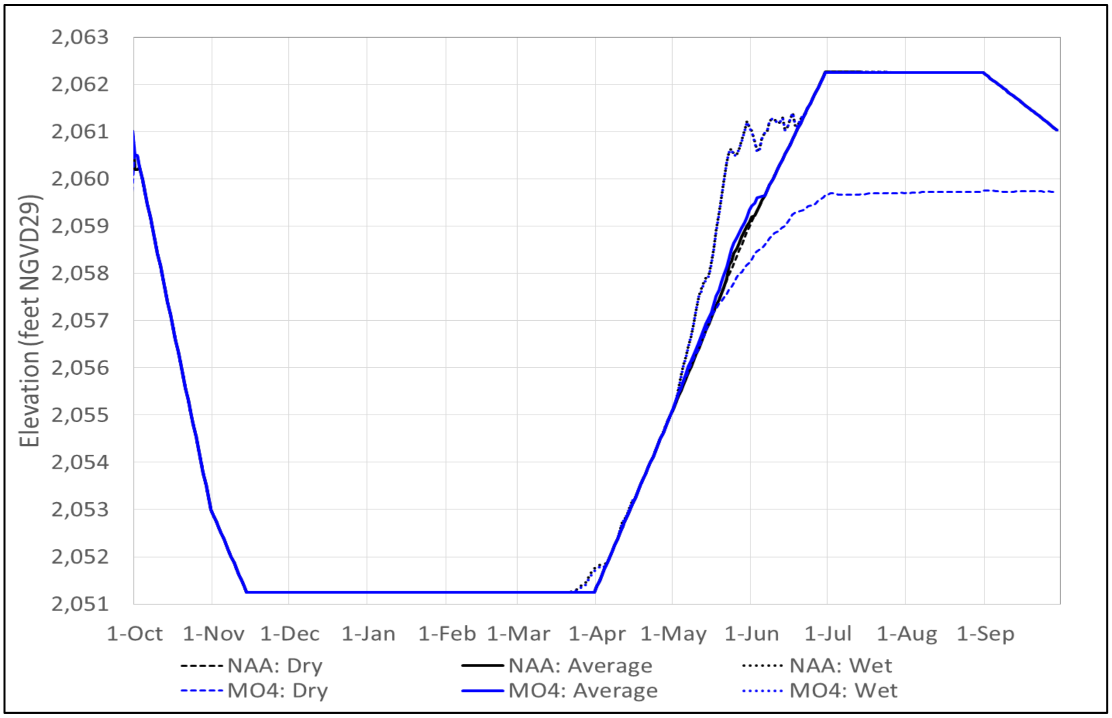



**Figure 3-87. Lake Pend Oreille Summary Hydrograph for Multiple Objective Alternative 4**

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

2957 


2958 **Figure 3-88. Lake Pend Oreille Water Year Type Hydrographs for Multiple Objective**
2959 **Alternative 4**

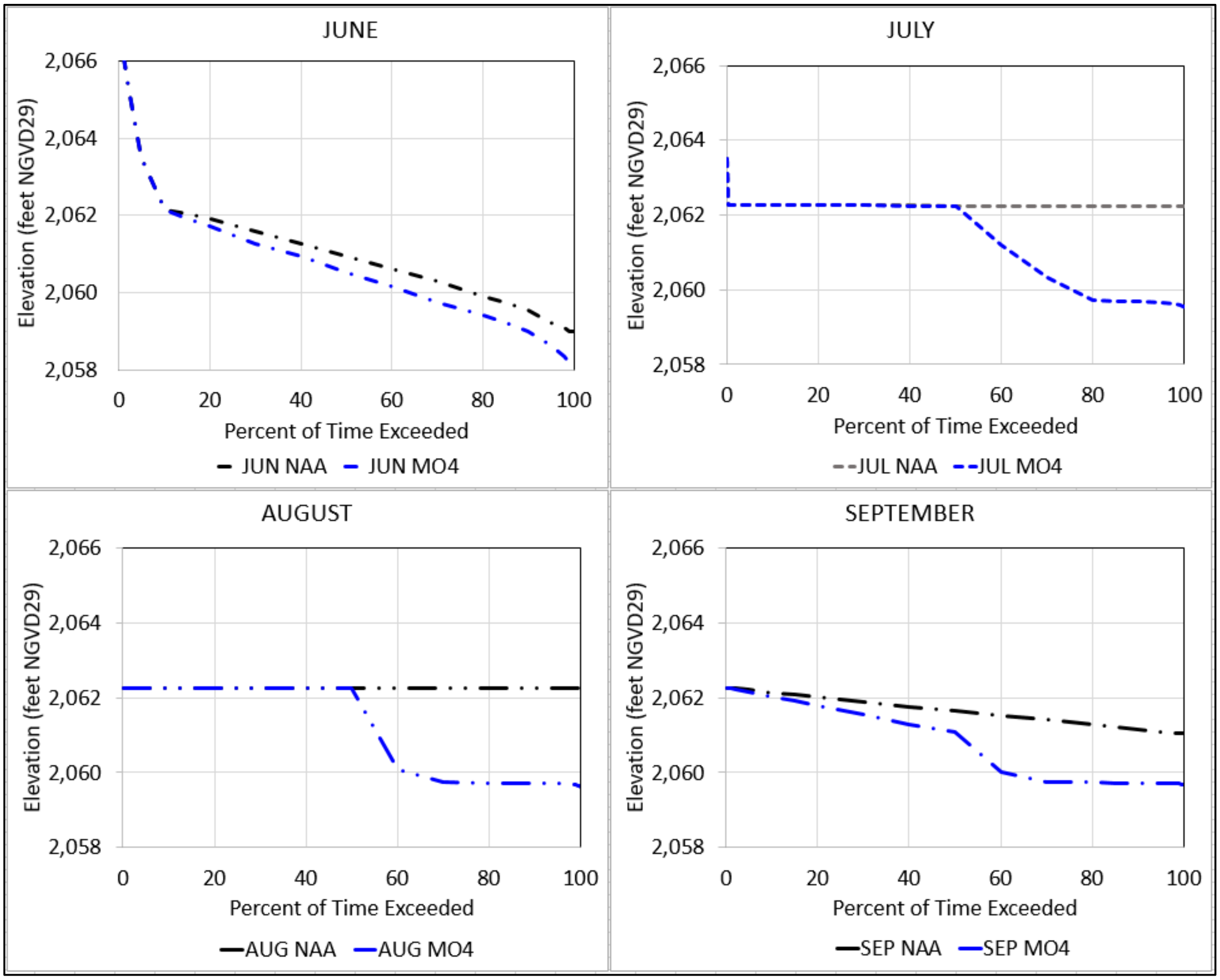



**Figure 3-89. Lake Pend Oreille Summer Elevations for Multiple Objective Alternative 4**

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.

### Albeni Falls Outflow

Under MO4, the *McNary Flow Target* measure would directly affect Albeni Falls Dam outflow. An indirect influence would come from the *Sliding Scale at Libby and Hungry Horse* and the *Hungry Horse Additional Water Supply* measures. The outflows would differ from the No Action Alternative as seen in Figure 3-90.

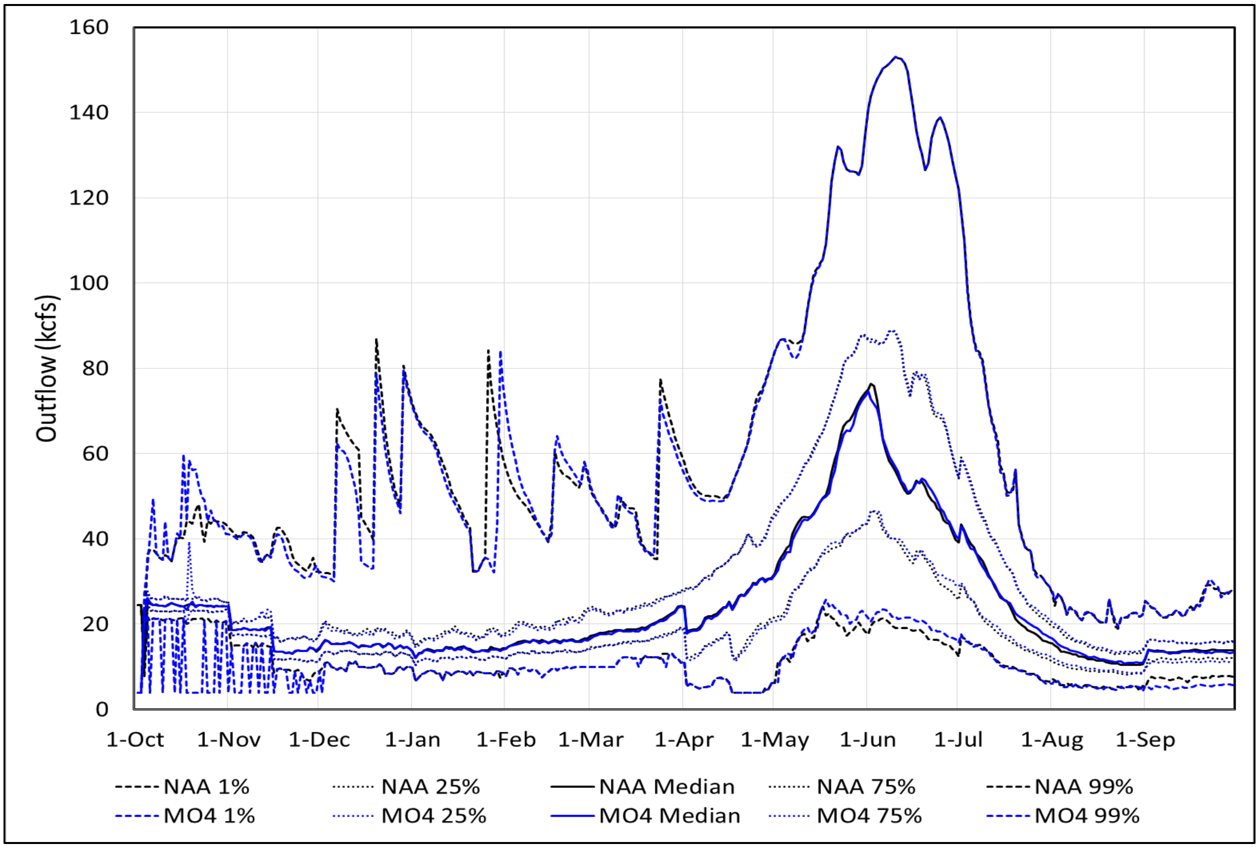



**Figure 3-90. Albeni Falls Dam Outflow Summary Hydrograph for Multiple Objective Alternative 4**

Note: The 99 percent exceedance values depicted for October/November are a modeling artifact related to ResSim model setup.

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

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

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

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

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

**Table 3-45. Pend Oreille Basin Monthly Average Flows for Multiple Objective Alternative 4 (as 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 | -0.1 | -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% |

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.

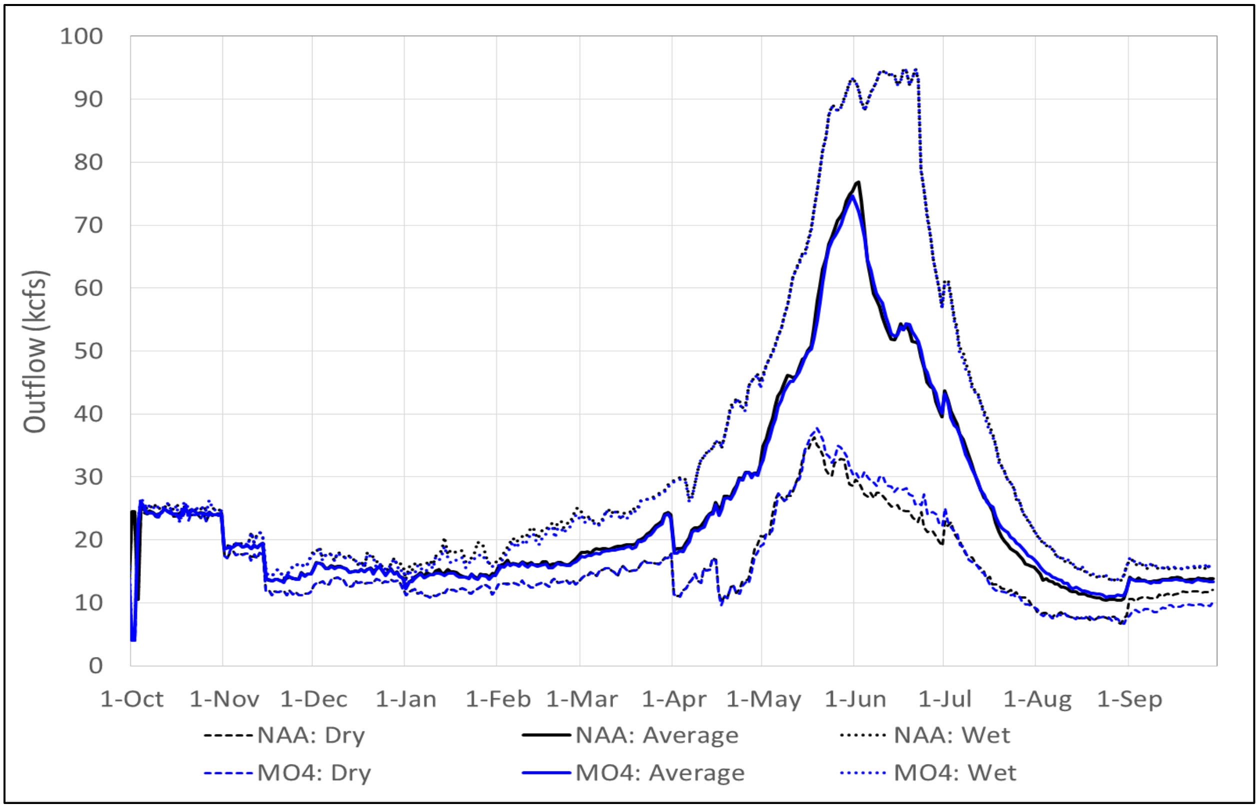



**Figure 3-91. Albeni Falls Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4**

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

### Columbia River flow upstream of Grand Coulee Dam

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

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

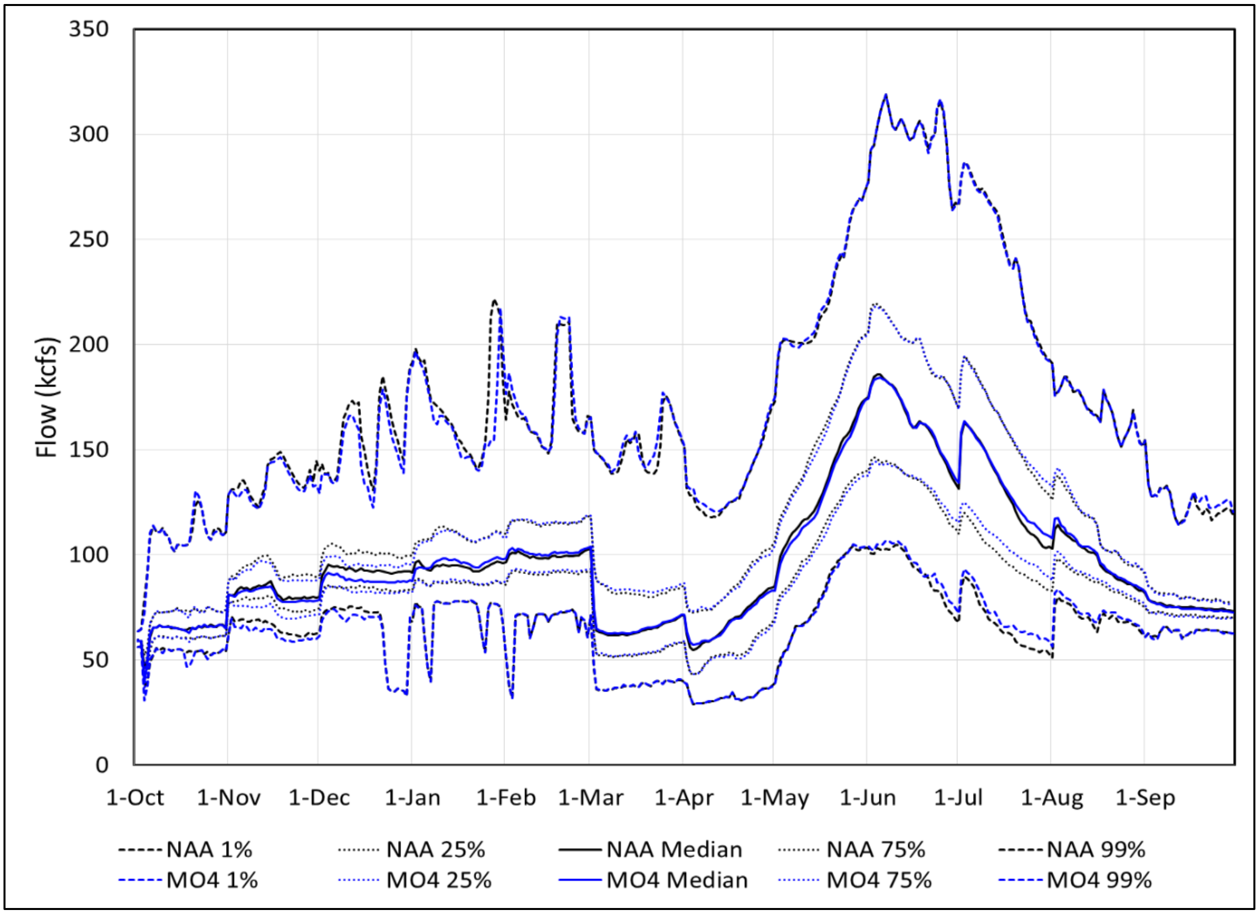



**Figure 3-92. Lake Roosevelt Inflow Summary Hydrograph for Multiple Objective Alternative 4**

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

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

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

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

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

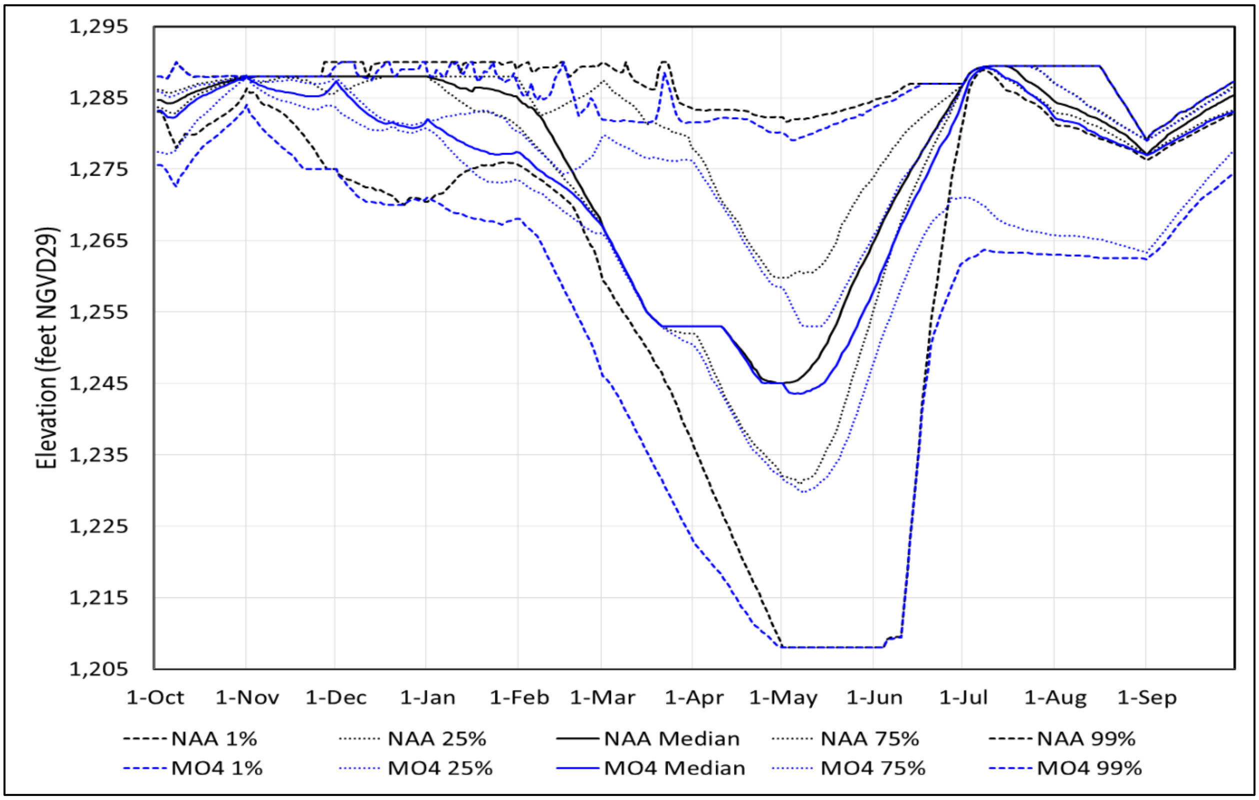



**Figure 3-93. Lake Roosevelt Summary Hydrograph for Multiple Objective Alternative 4**

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

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

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

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

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

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

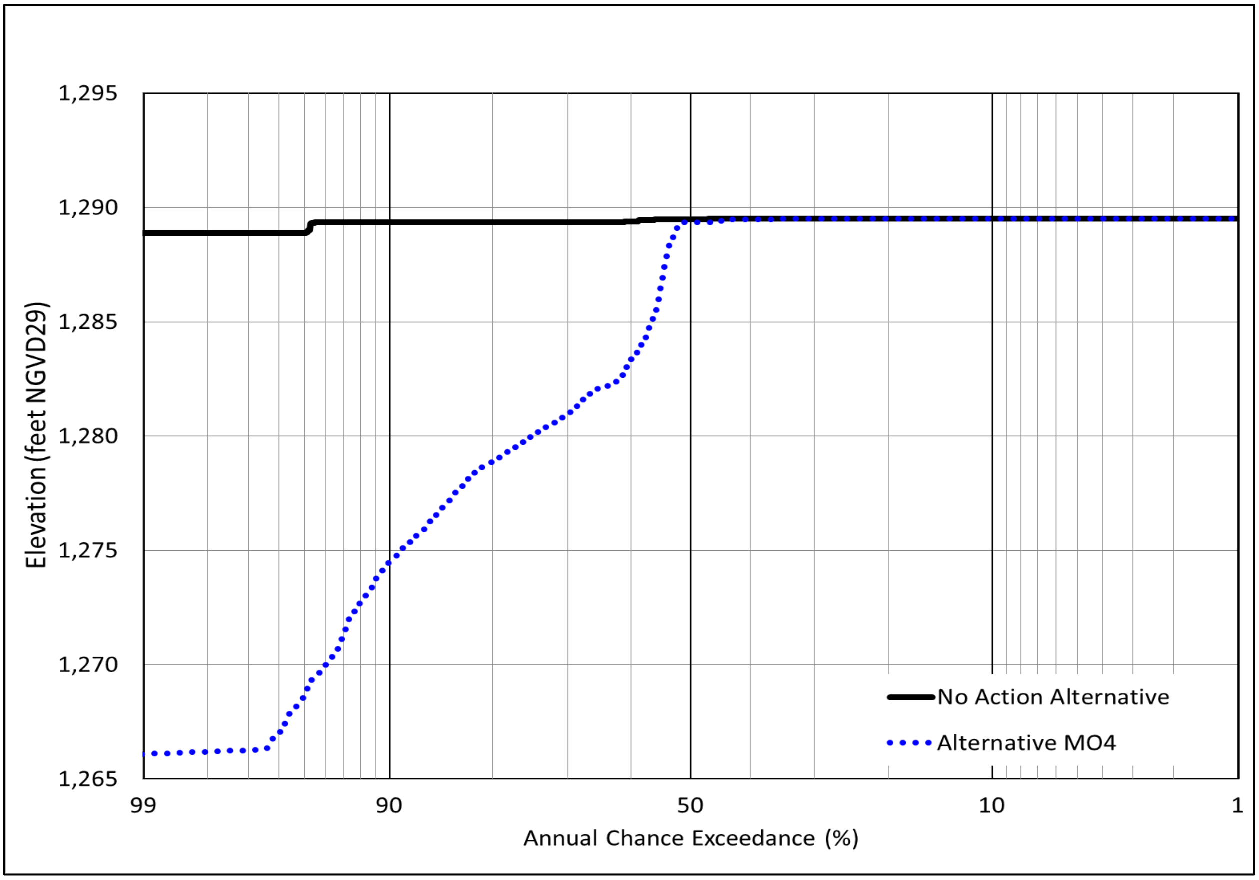



**Figure 3-94. Lake Roosevelt Peak Elevation Frequency for Multiple Objective Alternative 4**

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

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

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

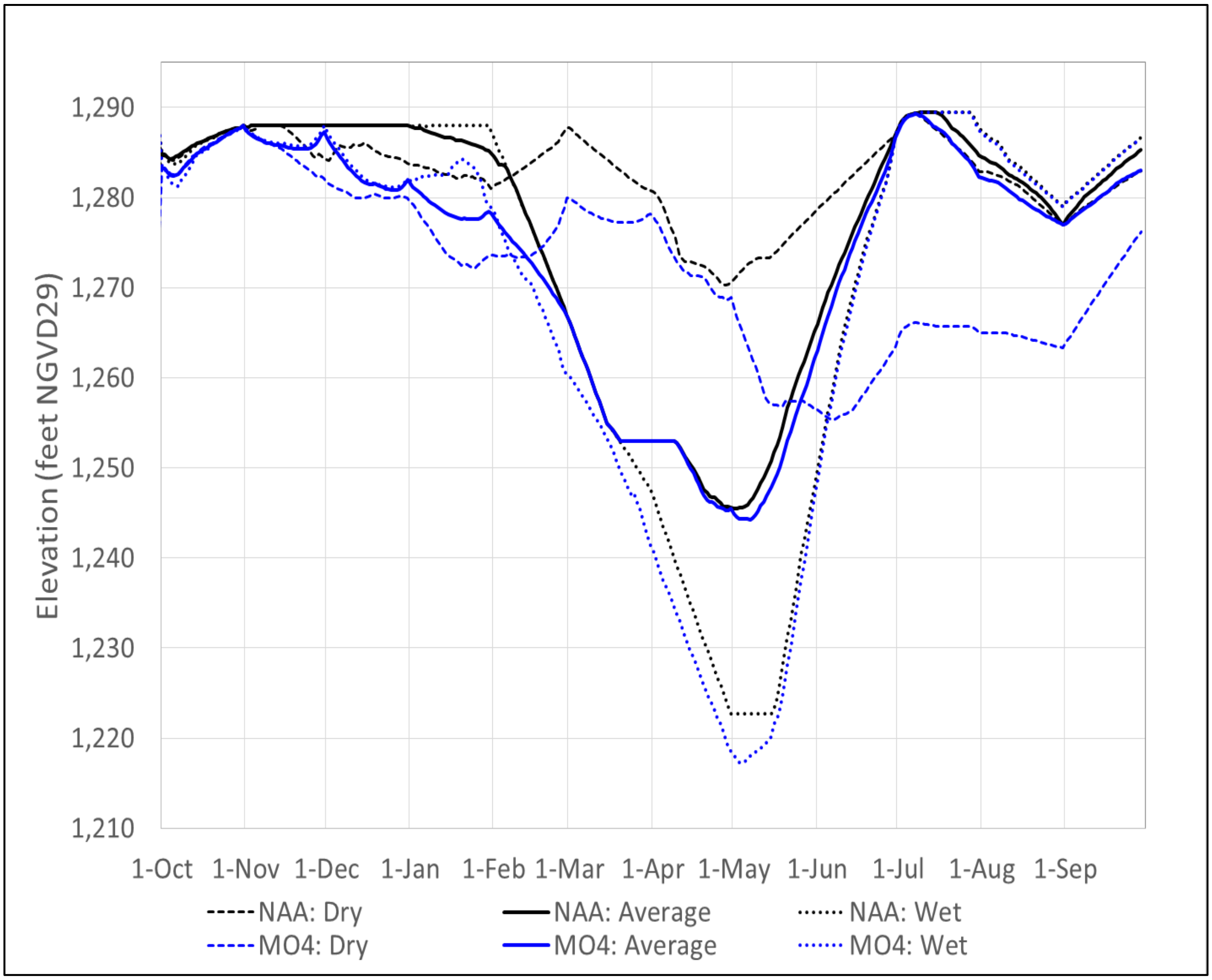



**Figure 3-95. Lake Roosevelt Water Year Type Hydrographs for Multiple Objective Alternative 4**

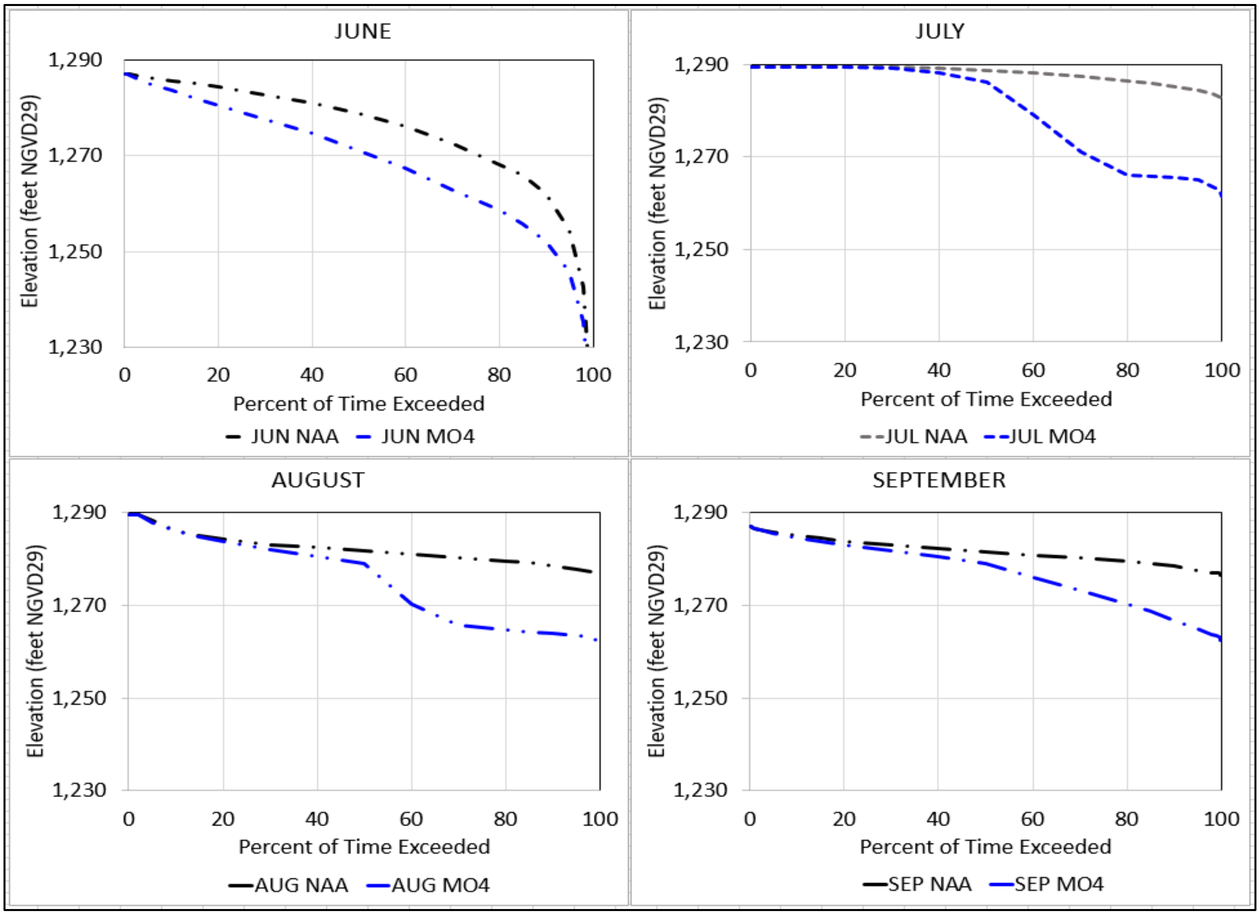



**Figure 3-96. Lake Roosevelt Summer Elevations for Multiple Objective Alternative 4**

**Grand Coulee Dam Drum Gate Maintenance**

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

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

### Grand Coulee Dam Outflow

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

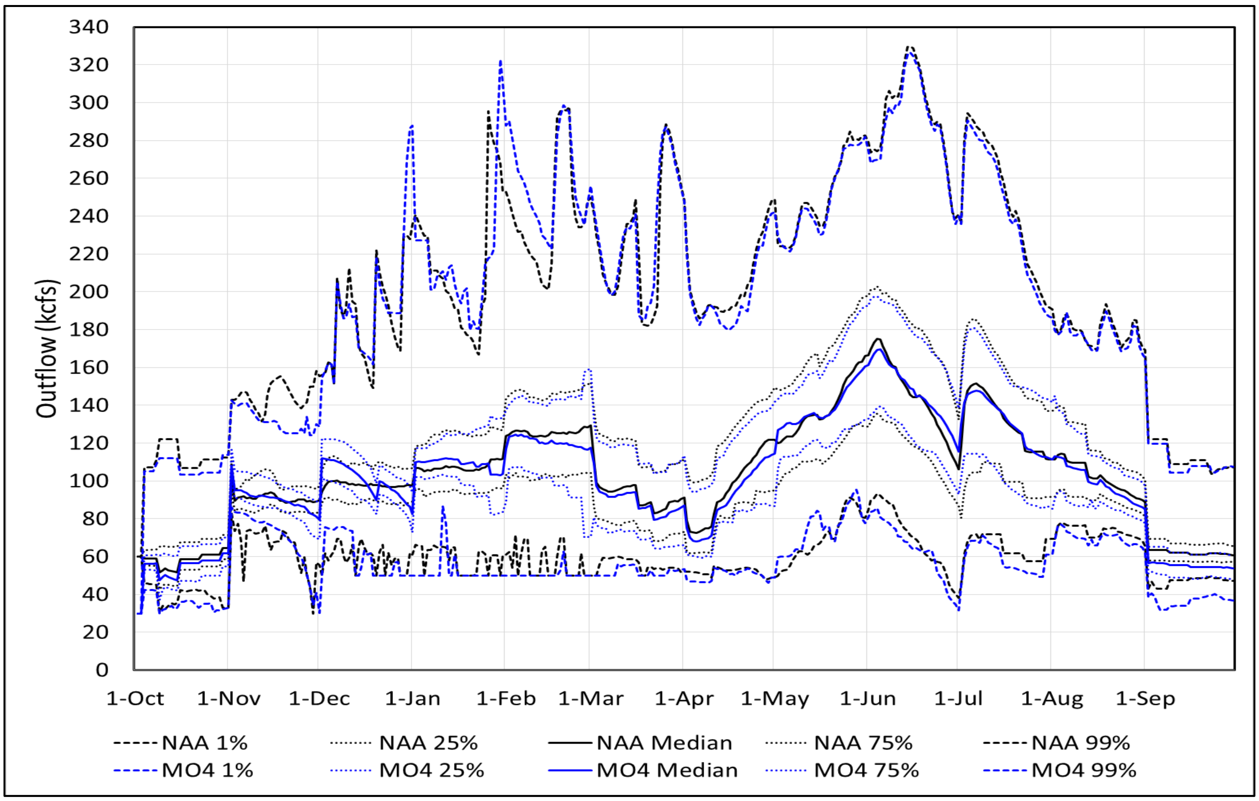



**Figure 3-97. Grand Coulee Dam Outflow Summary Hydrograph for Multiple Objective Alternative 4**

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

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

**Table 3-46. Grand Coulee 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% | 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 (kcfs) | 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% |

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.

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

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

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

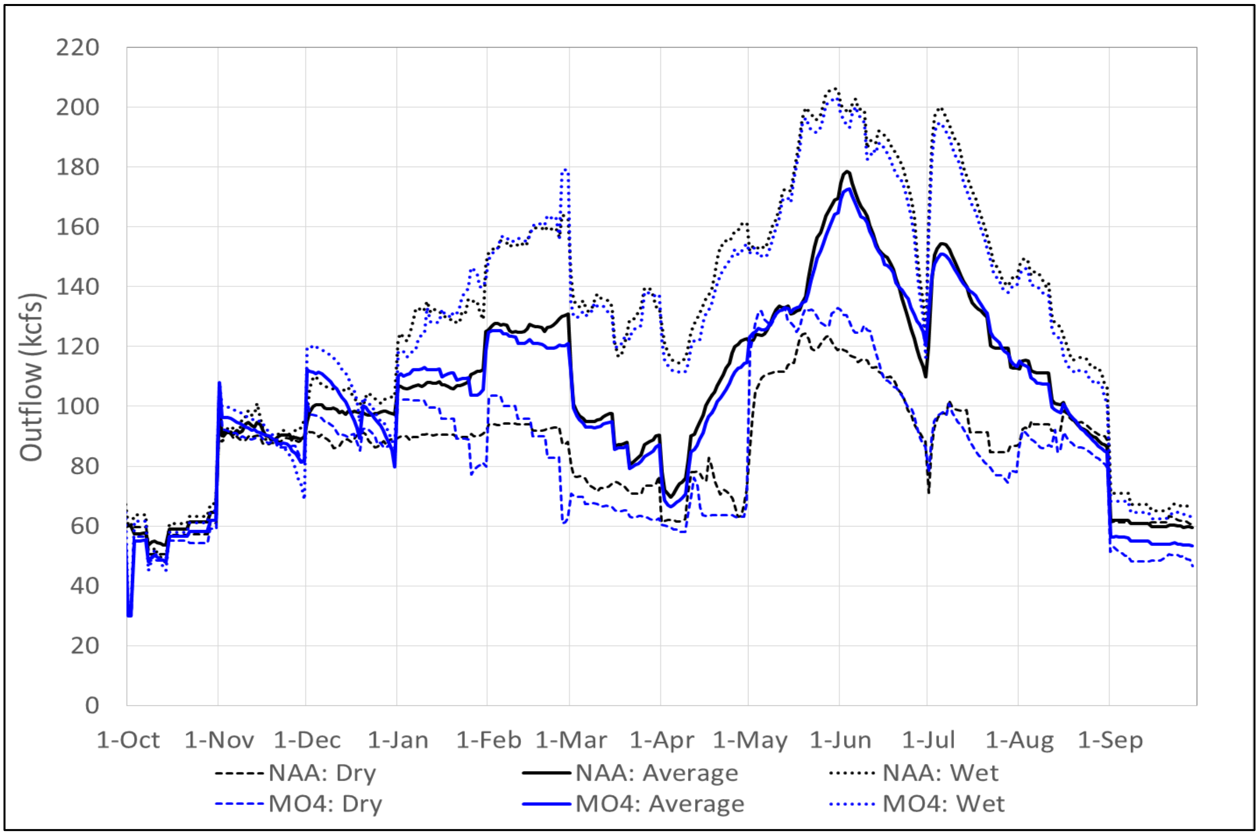



**Figure 3-98. Grand Coulee Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4**

### Middle Columbia River below Grand Coulee Dam

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

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

**Table 3-47. Middle Columbia River Monthly Average Flows for Multiple Objective Alternative 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% |

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.

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Dworshak Dam

MO4 does not have any operational measures that would directly affect Dworshak Reservoir elevations or Dworshak Dam outflows. Given this, the effects would be the same as those for the No Action Alternative.

### Lower Snake River Reservoir Elevations

Under MO4, the reservoir elevations at the four lower Snake River dams would have an adjusted MOP operation from March 15 through August 15 due to the *Drawdown to MOP* measure. At all four projects, the seasonal MOP range is increased from a 1.0-foot range to a 1.5-foot range, each with a 0.5-foot increase in the upper end of the range. The proposed elevation ranges for March 15 through August 15 at each of the four projects are described below:

- Lower Granite Dam: 733.0 to 734.5 feet NGVD29, compared to 733.0 to 734.0 feet NGVD29 for the No Action Alternative
- Little Goose Dam: 633.0 to 634.5 feet NGVD29, compared to 633.0 to 634.0 feet NGVD29 for the No Action Alternative
- Lower Monumental Dam: 537.0 to 538.5 feet NGVD29, compared to 537.0 to 538.5 feet NGVD29 for the No Action Alternative
- Ice Harbor Dam: 437.0 to 438.5 feet NGVD29, compared to 437.0 to 438.5 feet NGVD29 for the No Action Alternative

#### Clearwater River below Dworshak Dam and the Lower Snake River

Under MO4, there are no changes at Dworshak Dam, so inflow to the lower Snake River would be unchanged from the No Action Alternative. The changes in MOP ranges at the lower Snake River reservoirs would have negligible effects on flow.

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

#### Lower Columbia River Reservoir Elevations

Under MO4, there would be changes to the reservoir elevations at McNary Dam, John Day Dam, The Dalles Dam, and Bonneville Dam. All would have an adjusted operating range because of *Drawdown to MOP* measure, which results in decreased operating range from March 25 through August 15. The proposed MOP elevation ranges for each of the four projects and the changes from the No Action Alternative are described below:

- McNary Dam would have a 1.0-foot MOP range from March 25 to August 15 (337.0 to 338.0 feet NGVD29). This is a 2.0-foot decrease in operating range from the No Action Alternative, where McNary Dam does not have a MOP operation and the normal operating range is between 337.0 to 340.0 feet NGVD29.
- John Day Dam would have a 1.5-foot range from March 25 to August 15 (261.0 to 262.5 feet NGVD29). This differs from the No Action Alternative, where John Day Dam operates between 262.5 to 265.0 feet NGVD29 from March 15 to April 9, and between 262.5 to 264.0 feet NGVD29 from April 10 to September 30. In both periods, the new operating range minimum is shifted down 1.5 feet, and the range is decreased by 1.5 to 2.5 feet.
- The Dalles Dam would have a 1.5-foot MOP range from March 25 to August 15 (155.0 to 156.5 feet NGVD29). This is a 3.5-foot decrease in operating range from the No Action Alternative, where The Dalles Dam does not have a MOP operation and is operated between 155.0 to 160.0 feet NGVD29 year round.
- Bonneville Dam would have a 1.5-foot MOP range from March 25 to August 15 (71.5 to 73.0 feet NGVD29). This is a 3.5-foot decrease in operating range from the No Action Alternative, where Bonneville Dam does not have a MOP operation and is operated between 71.5 to 76.5 feet NGVD29 year round.

The operating range for John Day Dam for MO4 is shown in Figure 3-99. The No Action Alternative operating range is shown for comparison purposes.

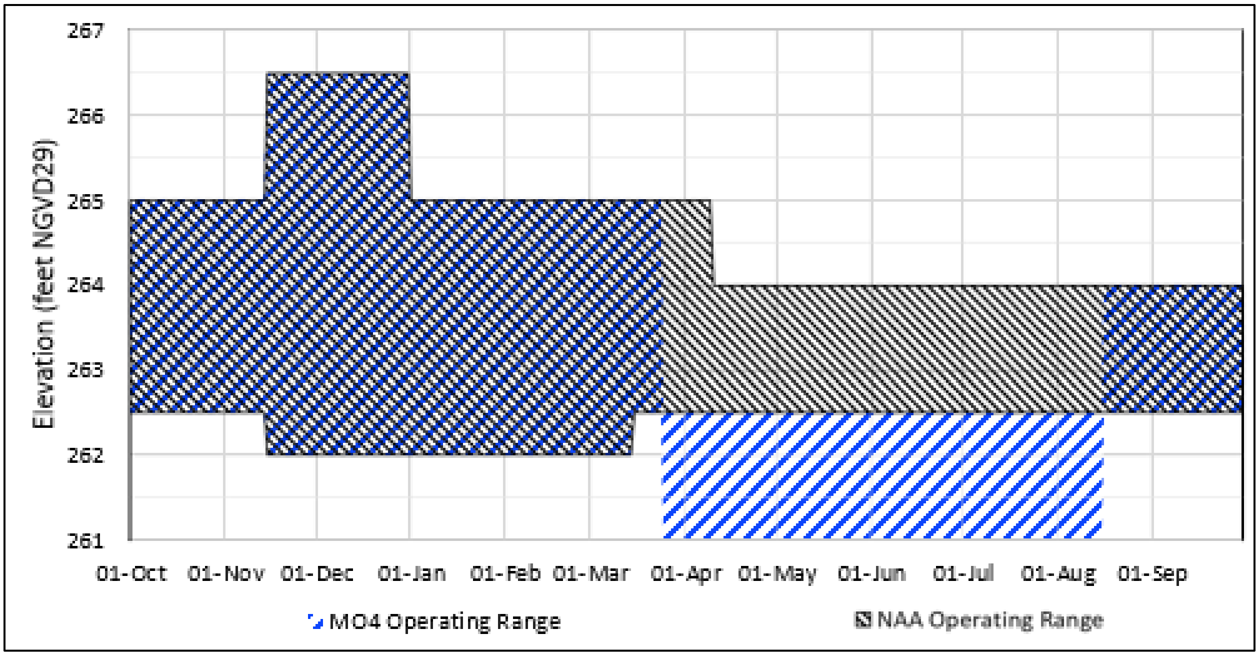



**Figure 3-99. John Day Dam Operating Range for Multiple Objective Alternative 4**

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

**Lower Columbia River Flows**

Under MO4, the *McNary Flow Target*, *Sliding Scale at Libby and Hungry Horse*, *Modified Draft at Libby*, *December Libby Target Elevation*, *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, *Winter System FRM Space*, *Lake Roosevelt Additional Water Supply*, *Hungry Horse Additional Water Supply*, *Chief Joseph Dam Project Additional Water Supply*, *Drawdown to MOP,* and *Winter Stage for Riparian* measures would cause changes in flow patterns in the lower Columbia River.

At McNary Dam, the outflows under MO4 would differ from the No Action Alternative to various extents through the water year. The magnitude and timing of differences in flow are displayed in the summary hydrograph, Figure 3-100. The flow spike that appears in mid-March, as well as the flow dip that appears in mid-August, are both related to the way that changes in pool levels were modeled for the *Drawdown to MOP* measure. This spike/dip would not be expected to occur in actual implementation, as the elevation changes for starting and ending MOP would be spread out over more than 1 day, thus smoothing out changes in releases.

In addition to the daily flow values depicted in Figure 3-100, the monthly average outflows from McNary Dam that would occur under MO4 were compared to those for the No Action Alternative, as shown in Table 3-48.

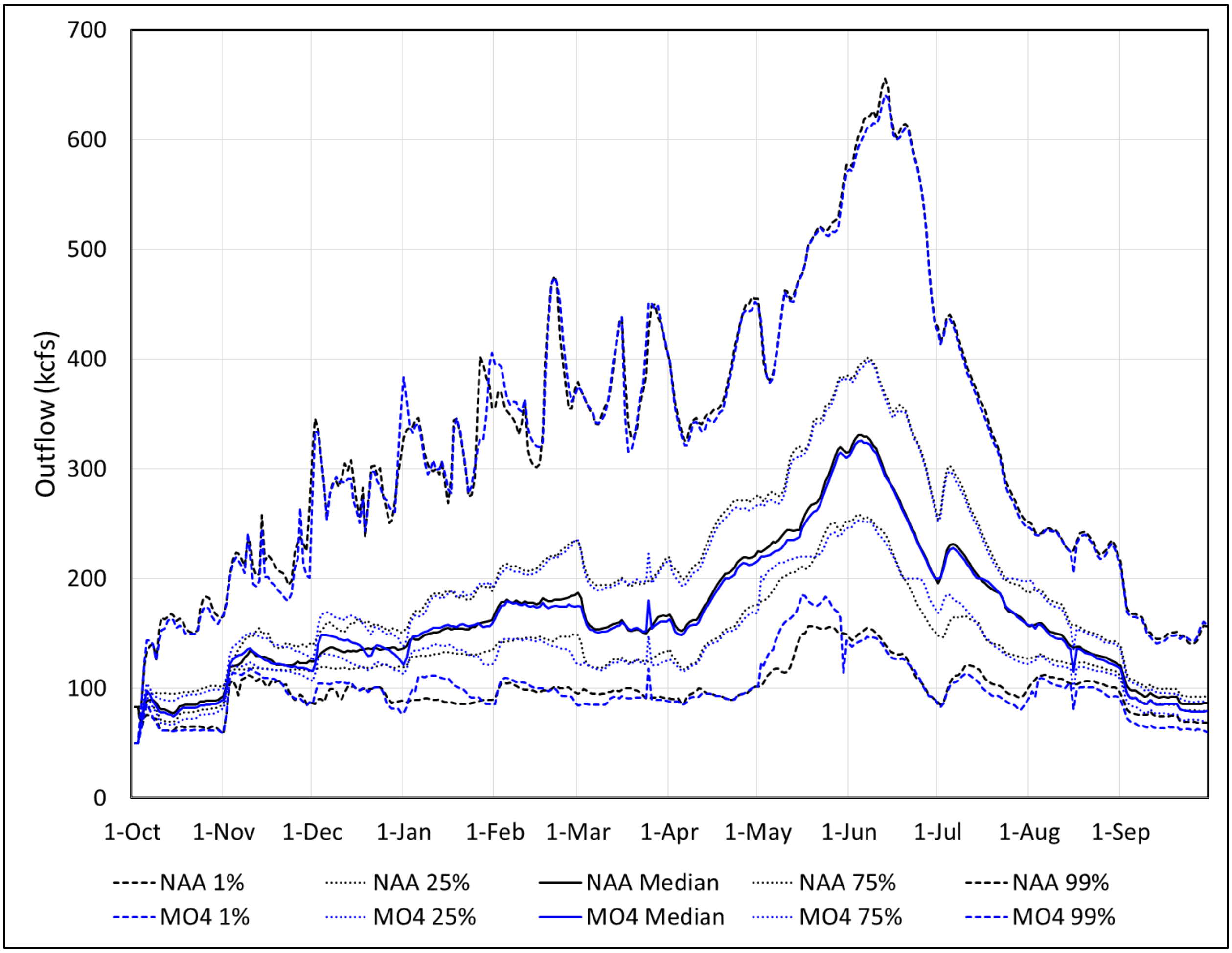



**Figure 3-100. McNary Dam Outflow Summary Hydrograph for Multiple Objective Alternative 4**

Several conclusions can be drawn from this comparison:

- In December and January, the median value of monthly average outflow would increase by 3.0 and 1.7 kcfs, respectively. There would be increases for other exceedance values as well. For instance, the 75 percent exceedance values in December and January would increase by 5.0 and 2.6 kcfs, respectively. The *Winter System FRM Space* measure calling for winter FRM space at Grand Coulee Dam is the main reason for these flow increases.
- In March and April, monthly average outflow would be less than the No Action Alternative at all flow levels.
- In May, June, and July, the 75 percent exceedance values of monthly average outflow would increase by 2.3, 8.9, and 6.1 kcfs, respectively. And in the very driest years (reflected in the 99 percent exceedance value), the monthly average outflow in May would be 21.5 kcfs higher than for the No Action Alternative. The *McNary Flow Target* measure is the main reason for these flow increases.
- In August, September, October, and November, monthly average outflow would be less than the No Action Alternative at all flow levels.

**Table 3-48. McNary 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% | 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% |

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.

Finally, median hydrographs for McNary Dam outflow in dry, average, and wet years are shown in Figure 3-101. MO4 and the No Action Alternative results are shown. With the results categorized by water year type, it is readily seen that the *McNary Flow Target* measure's flow objective of 220 kcfs in the spring would generally be achieved. The summertime objective of 200 kcfs (from June 16 to July 31), which is also part of the *McNary Flow Target* measure, would generally not be achieved in average and dry years. In September, the flows at McNary Dam under MO4 would be lower than for the No Action Alternative in average and dry years, with the difference being most pronounced in dry water years.

Along the lower Columbia River, the median value of the average monthly flow for MO4 would be higher than the No Action Alternative in some months (for example, December, January, and July), and lower in others (for example, April, May, June, August, and September). The flow change patterns seen at the confluence of the Columbia and Snake Rivers continue downstream to other locations. This is seen in Table 3-49.

With the exception of effects of the *Drawdown to MOP* measure at John Day, the effects on McNary Dam outflow from MO4 would occur similarly, and for the same reasons, at John Day Dam, The Dalles Dam, and Bonneville Dam. The measure would result in an increase in March flows and a decrease in August, reversing the flow trend shown in the McNary Dam outflow for March, and adding to the decrease shown in August.

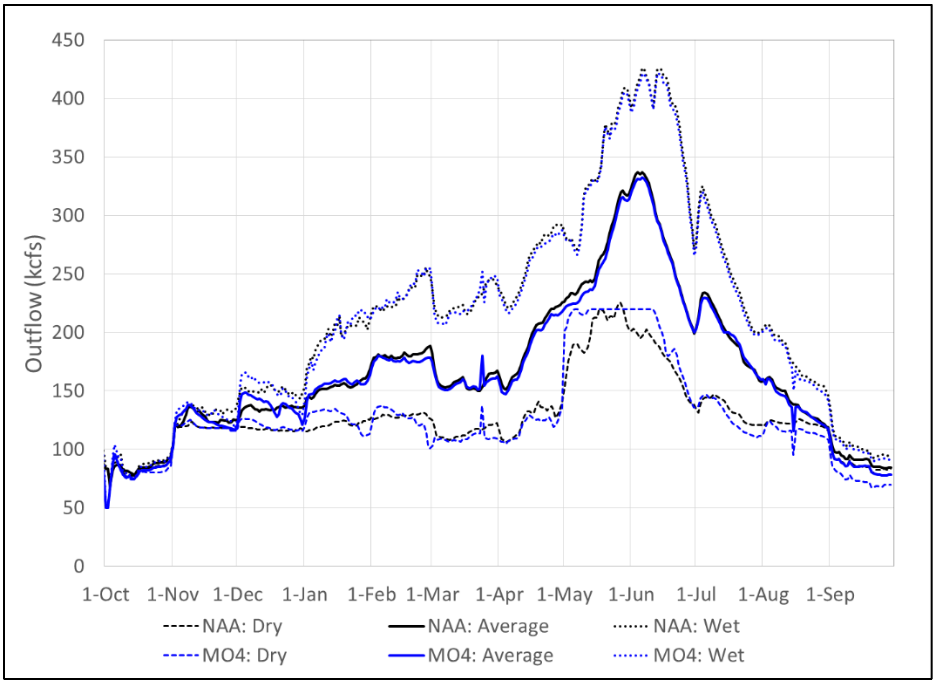



**Figure 3-101. McNary Dam Outflow Water Year Type Hydrographs for Multiple Objective Alternative 4**

**Table 3-49. Lower Columbia River Monthly Average Flows for Multiple Objective Alternative 4 (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% |

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

**SUMMARY OF EFFECTS**

Under MO4, the largest changes in water levels occur at Libby, Grand Coulee, and the lower Columbia River dams. Lake Koocanusa water levels are less variable in the winter and spring, with deeper drafts in low forecast years and less-deep drafts in large forecast years. August through November reservoir levels are lower in most years but can be higher in higher forecast years. Lake Roosevelt water levels are notably lower in the winter due to additional winter FRM space, slightly higher later in the year, and notably lower in the summer into the fall in low forecast years. At Hungry Horse Reservoir, additional water demand in the summer months results in slightly lower reservoir levels for most of the year, particularly in a low forecast year at The Dalles. The forebay operating range is slightly higher in the summer months at the lower Snake River projects and notably lower at the lower Columbia River projects. There are no changes at Dworshak Dam.

Changes in Libby outflows vary greatly across the year; November and December releases are decreased, winter releases after December are notably higher, April and May releases are lower, and summer releases are higher, particularly in June and July in low forecast years at The Dalles. Due to additional water demands from Hungry Horse Dam, Flathead River flows are lower in winter and spring months. In low forecast years at The Dalles, Hungry Horse and Albeni Falls Dams release extra water in June and July, and these are followed by larger decreases in flow in the fall and winter months. Water supply delivery increases from Grand Coulee and Chief Joseph Dams contribute to lower spring and summer flows in the Columbia River downstream. In low forecast years at The Dalles, flows are increased May through July, and then further decreased in September and October. With the exception of September, which can be more than 10 percent lower in lower water years, changes in average monthly flow through the lower Columbia River are typically within 5 percent of the No Action Alternative for all months for typical years.

## 3.3 RIVER MECHANICS

This river mechanics section consists of four parts: (1) a description of the study area, (2) a summary of the baseline sediment transport and geomorphologic conditions for the study area, (3) a discussion of the methodology and quantitative metrics, and (4) an estimate of the potential impacts to river mechanics metrics under the No Action Alternative and four MOs. Relative impacts are then compared between the MOs and No Action Alternative. See Chapter 7 for a description of impacts to river mechanics as a result of implementing the draft preferred alternative.

### 3.3.1 Area of Analysis

For the geomorphology and sediment transport discussions, the area of analysis is the CRS reservoirs and the river reaches downstream that are within the borders of the United States. River mechanics effects for reaches in Canada downstream of CRS reservoirs would be expected to be similar to the effects described in neighboring river reaches in the United States. Discussion of reaches in this chapter is organized by the four physiographic NEPA regions listed in Table 3-50 and depicted in Figure 3-102. Within each of the four lettered CRSO regions, the river mechanics analyses were subsequently grouped by the following: major reach, minor reach, and subreach, each representing a finer resolution level. In general, major reaches coincide physiographically with river segments or groups. Minor reaches were defined as reservoir or river segments between FCRPS projects, and subreaches were delineated by contiguous similarity in physical properties such as the following: valley type, morphology, energy grade slope, and flow depth. More information regarding the reach delineations is presented in Appendix C.

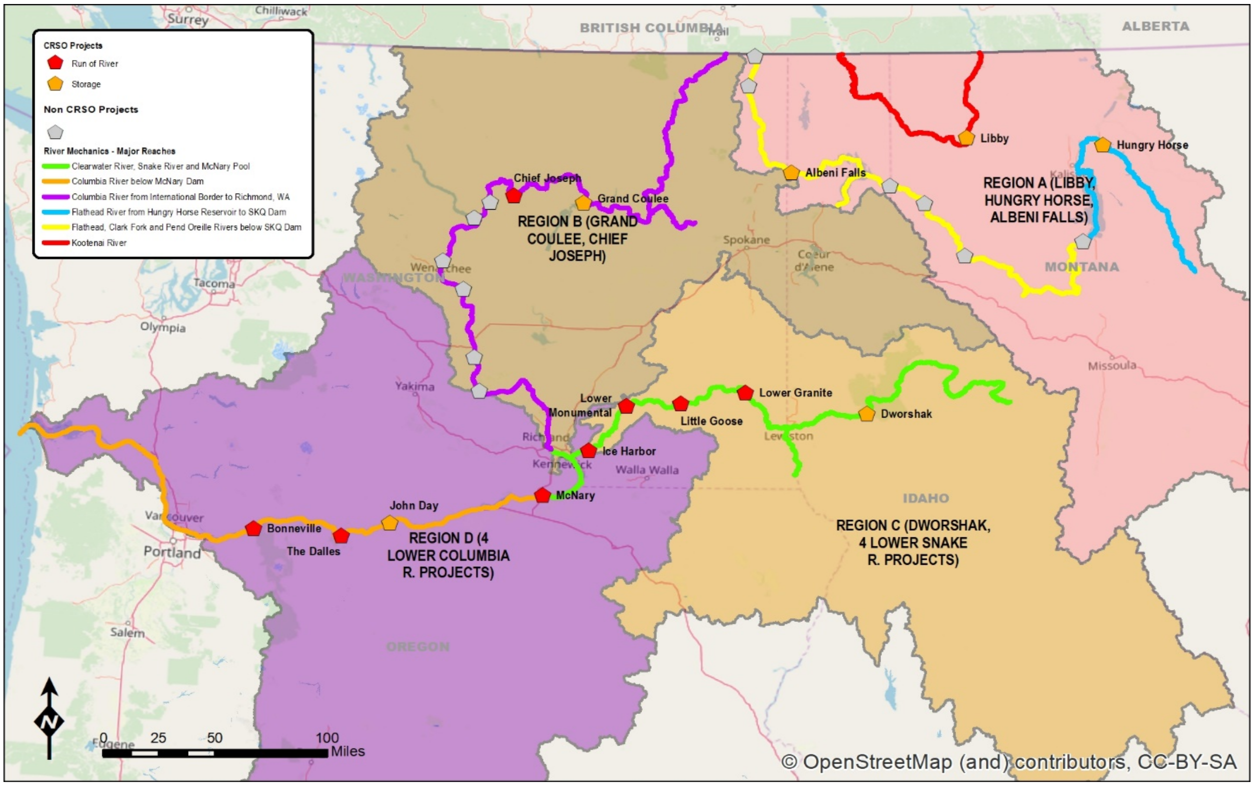



**Figure 3-102. Overview Map of Study Area Regions Used for River Mechanics Assessment**

**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 |

### *3.3.1.1 Region A – Kootenai, Flathead, and Pend Oreille Basins*

Region A includes the Kootenai, Flathead, and Pend Oreille Basins. There are nine hydroregulation projects located within Region A. Only three of the projects are CRS projects operated for storage (Libby Dam, Hungry Horse, and Albeni Falls). The remaining six projects (SKQ, Thompson Falls, Noxon Rapids, Cabinet Gorge, Box Canyon, and Boundary) are not part of the CRS but were included in the hydroregulation planning model to quantify potential departure in metrics that could result due to operational changes between the upper basin storage projects and the Columbia River.

#### REGION A – KOOTENAI RIVER

The Kootenai(y) River major reach lies within the NEPA Region A. The Libby Dam reservoir (Lake Koocanusa) extends upstream across the U.S.-Canada border, which forms the upstream end of the study area. The upper 70 miles of the Kootenai River is free flowing between Libby Dam and

Bonners Ferry, Idaho. Downstream of Bonners Ferry is a backwatered reach which flows back across the U.S.-Canada border to Kootenay Lake, B.C., marking the downstream analysis extent.

**REGION A – FLATHEAD RIVER FROM HUNGRY HORSE RESERVOIR TO SKQ DAM**

The Flathead River from Hungry Horse Reservoir to SKQ Dam major reach lies within NEPA Region A and spans approximately 85 river miles. The Hungry Horse storage project lies within this major reach, and the upstream extent of Hungry Horse Reservoir coincides with the upstream extent of the study area. The Flathead River analysis area is free-flowing for approximately 28 river miles from the Hungry Horse Dam tailrace upstream to the confluence with the Stillwater River downstream. From there, the lower 20 river miles of the Flathead River are seasonally backwatered by Flathead Lake, which inundates the lower 35 miles of the reach.

**REGION A – FLATHEAD, CLARK FORK, AND PEND OREILLE RIVERS BELOW SKQ DAM**

The Flathead, Clark Fork, and Pend Oreille Rivers below SKQ Dam major reach lies within NEPA Region A. SKQ Dam on the Flathead River marks the upstream extent of this major reach. The Pend Oreille River, flowing across the U.S.-Canada border, marks the downstream reach extent. The Lower Clark Fork River subreach extends approximately 109 river miles from the confluence with the Flathead River upstream to Lake Pend Oreille downstream.

There are three non CRS run-of-river projects within the subreach: Thompson Falls, Noxon Rapids, and Cabinet Gorge, which can locally influence Clark Fork River hydraulics. The Pend Oreille River subreach spans approximately 118 river miles between the Clark Fork River Delta on Lake Pend Oreille upstream to Boundary Dam downstream at the U.S.-Canada border in northeast Washington. There is one CRS storage project (Albeni Falls) and two non-CRS run-of-river projects (Box Canyon and Boundary) that influence hydraulics within the reach. Downstream of Boundary Dam, the Pend Oreille River flows north into Canada where it joins the Columbia River approximately 17 miles downstream near Waneta Dam, B.C.

### *3.3.1.2 Region B – Middle Columbia River*

Region B includes the middle Columbia River Basin as it enters the United States from Canada. The middle Columbia River Basin analysis reach spans approximately 413 river miles from the U.S.-Canada border upstream in northeastern Washington to Richland, Washington, downstream near the Yakima River confluence. The downstream extent of this major reach ends at the transition from the free-flowing Hanford Reach to the backwatered McNary Reservoir.

There are seven hydroregulation projects located within Region B (Grand Coulee, Chief Joseph, Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids). Only one of the Region B projects (Grand Coulee) is operated for storage; two of the projects (Grand Coulee and Chief Joseph) have modified operational measures under the CRSO EIS. The remaining five private non-Federal projects downstream of Chief Joseph are all run-of-river and are not part of the CRS; however, they were included in the hydroregulation planning model to quantify potential departure in metrics that could result due to operational changes between Lake Roosevelt upstream and the lower Columbia River downstream.

#### *3.3.1.3 Region C – Clearwater and Lower Snake Rivers*

Analysis Region C includes the Clearwater and lower Snake River Basins in western Idaho and eastern Washington. There are five hydroregulation projects located within Region C that have modified operational measures under the CRSO EIS. Only one of the projects (Dworshak) on the Clearwater River is operated for storage, while the remaining four on the lower Snake River below Lewiston, Idaho (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor), are run-of-river projects. The Clearwater River study minor reach spans approximately 42 river miles from Dworshak Dam to the confluence with the Snake River near Lewiston, Idaho. The lower Snake River minor reach spans approximately 168 river miles from above the Grande Ronde River confluence upstream to the Columbia River confluence near Pasco, Washington, downstream. There is an authorized navigation channel between the Snake River confluence with the Columbia River and the city of Lewiston, Idaho, in the Lower Granite Reservoir that is part of this major reach.

#### *3.3.1.4 Region D – Lower Columbia River*

Region D includes the Columbia River below Richland, Washington. There are four hydroregulation projects located within Region D that have modified operational measures under the CRSO EIS (McNary, John Day, The Dalles, and Bonneville Dam). These projects generally operate as run-of-river projects, even though there is a small amount of storage at John Day Dam. The upstream extent of Region D begins at the downstream extent of Region B near the confluence of the Columbia and Yakima Rivers as well as the downstream extent of Region C (at the confluence of the Columbia and Snake Rivers). The lower Columbia River reach extends approximately 316 river miles from the confluence with the Yakima River upstream to the mouth of the Columbia River downstream near Astoria, Oregon. There is an authorized navigation channel between RM 3 near the Pacific Ocean and McNary Reservoir that is also part of this major reach.

### 3.3.2 Affected Environment

For this EIS analysis, river mechanics response in the analysis area is a combined function of the following: hydrology, sediment supply, and hydraulic response which is driven by slope, channel geometry, and roughness. Hydraulic response within the system is characterized by three major types: storage reservoirs, run-of-river reservoirs, and free-flowing reaches. The baseline characteristics for the affected environment analysis area are summarized in the following section.

#### *3.3.2.1 Hydrology*

The typical mean daily flows throughout the year at a few key locations in the Columbia River Basin are shown in Figure 3-103. The largest alteration to flow occurs at storage dams, which are operated to balance various flow release and water storage needs according to the operational goals for each project. Because of flow regulation, high discharges during the flood season (spring freshet period) are less frequent than during pre-regulation (pre-1930s) times; conversely, there are typically higher discharges during the summer and fall than during pre-regulation times.

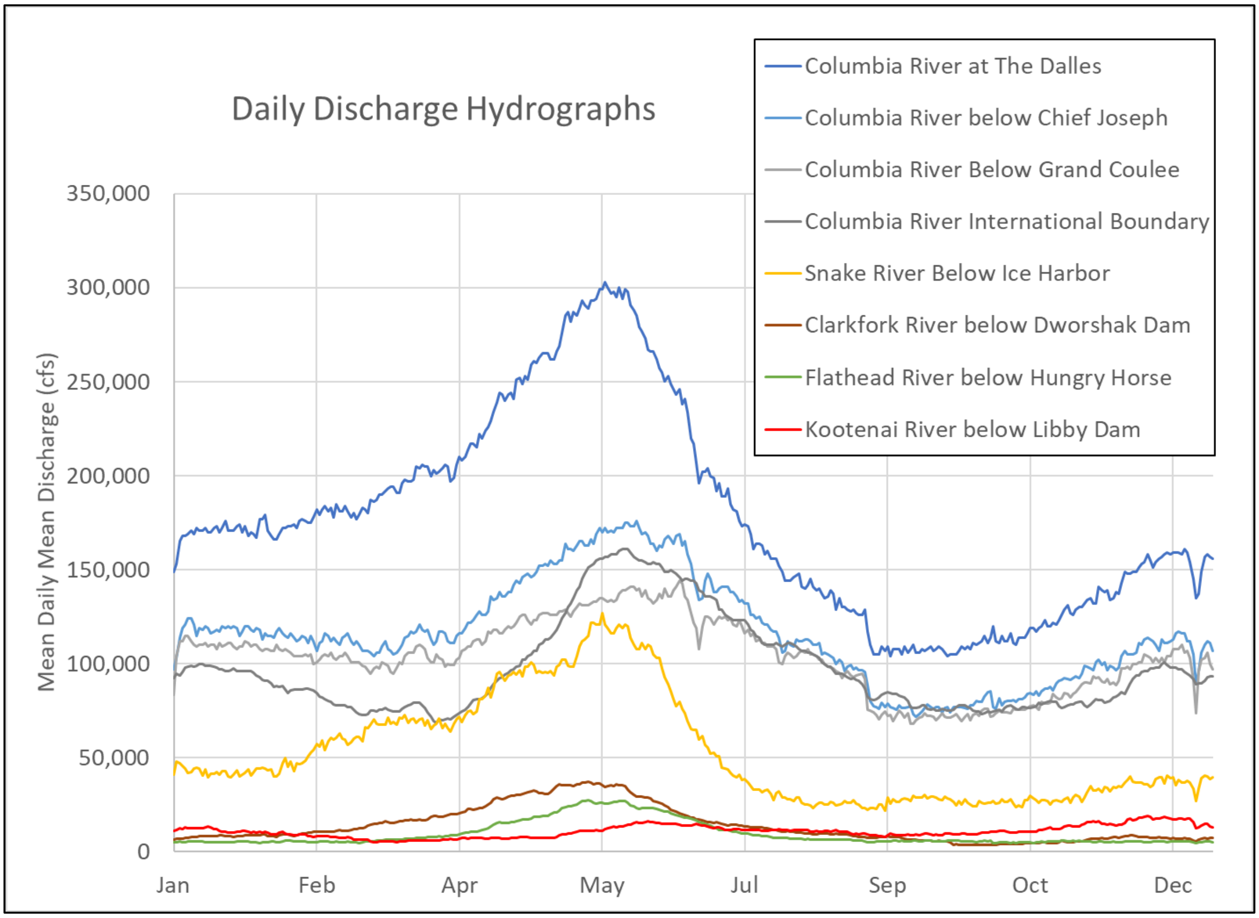



**Figure 3-103. Mean Daily Mean Discharges at U.S. Geological Survey Gages**

Note: Data is for water years 1977 to 2017 downstream of storage dams, at Chief Joseph Dam, at Ice Harbor Dam just upstream of the confluence of the Snake River with the Columbia River, and at the U.S.-Canada border.

#### *3.3.2.2 Sediment Supply*

Very little sediment crosses the U.S.-Canada border because upstream dams trap it. Primary mechanisms of sediment delivery to the Columbia River Basin between Grand Coulee and Bonneville Reservoir are landslides and bank erosion that contribute fine-grained sediment that is mostly transported in suspension (e.g., Alden 1953; Kiver and Stradling 1995; Washington Division of Geology and Earth Resources 2016a, 2016b; Washington Geological Survey 2017a, 2017b). From Bonneville Reservoir downstream, sediment is largely sourced from volcanic rocks and is typically coarse grained, contributing to bedload (Whetten, Kelley, and Hanson 1969). Overall, tributaries that produce the greatest volumes of sediment include the Snake, Okanogan, Yakima, and Palouse Rivers (Whetten, Kelley, and Hanson 1969). Sediment deposits in river reaches now occupied by reservoirs are also subject to shoreline erosion. This is especially true during filling of reservoirs, periods with fluctuating water levels, and reservoir drawdowns (e.g., Schuster 1979; Cox et al. 2005). Wave energy can cause shoreline erosion following reservoir filling; however, if reservoir levels are maintained, the shoreline may eventually approach an equilibrium profile (e.g., Lorang, Komar, and Stanford 1993), decreasing the sediment yield from shoreline erosion over time.

Sediment supply and transport is affected by dams and flow regulation. Mainstem and tributary dams trap sediment by changing hydraulic conditions in their impoundments and reducing sediment supply in downstream river reaches. Flow regulation and the reduction of peak flows through dam operations further reduce sediment transport capacity. Because sediment transport capacity is much greater at high flows than low flows, reducing the magnitude of high flows can reduce the overall capacity of a reach to move sediment. The primary sediment sources in the Columbia River Basin are incoming sediment load from reaches and tributaries upstream of a given location, point sources such as landslides and debris flows contributed from hillslopes along the river and reservoir reaches, and locally eroded sediment from the channel bed, river banks, reservoir shorelines, and floodplains. However, most of the reaches evaluated have more than 90 percent of the upstream drainage area affected by upstream dams, which alters the incoming flow and greatly reduces the incoming sediment supply. A few exceptions include Hungry Horse Dam (Flathead River), Libby Dam (Kootenai River), and Dworshak Dam (North Fork Clearwater River) with largely unaltered incoming river flow and sediment supply due to the relatively pristine conditions of the upper watersheds. Existing sediment inputs to the reaches are described below to provide context for potential changes in sediment transport under the No Action Alternative and MOs.

The current average annual sediment load in the Columbia River at Vancouver, Washington, has been reduced by an estimated 58 percent from pre-1930s conditions (Sherwood et al. 1990). This reduction in total sediment load is biased toward coarse sediment, with an 80 percent reduction in sands and a 42 percent reduction in silts and clays from pre-1930s conditions. The total reduction in sediment load can be attributed to multiple factors including reduction in peak flows due to system regulation and land use practices, as well as trapping of sediments in the reservoirs. With an estimated pre-1934 total load at Vancouver at 18.5 million tons per year, the 241,000-square-mile basin upstream of Vancouver has historically been a low-sediment-yield basin relative to other major rivers with an average of 77 tons per square mile. This yield per square mile is 28 percent of the Mississippi River and 7 percent of the Colorado River suspended load yield, for comparison (Holman 1968).

#### *3.3.2.3 Storage Reservoirs*

In the CRS, there are six dams that are designed and operated for flood, irrigation, or other storage purposes: Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day and Dworshak. In this analysis, John Day Dam is included in both the storage project and run-of-river categories. While John Day is authorized for FRM, it has limited storage capacity and is operated more like a run-of-river project where the project does not store incoming flow. Operators change the pool elevation at these storage projects over large ranges throughout the year to capture and release water in specifically designed ways.

**HEAD OF RESERVOIR SEDIMENT MOBILIZATION**

All reservoirs formed by dams on natural watercourses trap some sediment over time. Sand, gravel, and cobbles entering a reservoir as bedload typically deposit as a delta in the upstream end of reservoirs and along the upstream river channels as the flow of the river encounters backwater from the reservoir, slowing velocities and spreading out flow through multiple channels (Figure 3-104). Sediment deposited in the delta (commonly referred to head of reservoir deposits) can be remobilized farther downstream when the reservoir operating pool lowers (during reservoir drawdown), or during floods when sediment transport capacity is increased. In dams that operate over a wide range of elevations throughout the year, the upstream extent of reservoir backwater may shift considerable distances. Very fine, suspended silts and clays tend to transport past the delta and slowly settle out of the water column along the reservoir bottom as a lakebed deposit. Reservoirs with large storage volumes relative to the annual volume of water passing through the reservoir tend to trap more suspended sediment than reservoirs with smaller relative storage volumes.

If reservoir drawdown leaves the delta exposed to riverine conditions during high flow periods, the upper layers of the delta are often eroded and transported further into the reservoir, potentially increasing turbidity and downstream sediment deposit thickness. Changes in storage project elevations or changes to the flow of water and sediment into the reservoir can result in changes to the delta erosion and deposition patterns. This metric compares the paired relationships of flow and stage over time to indicate potential for change in sediment mobilization at the head of reservoir for each alternative. Changes in delta sediment mobilization could alter the sediment load farther downstream within the reservoir and potentially the amount of sediment passing a dam, particularly during high flow periods.

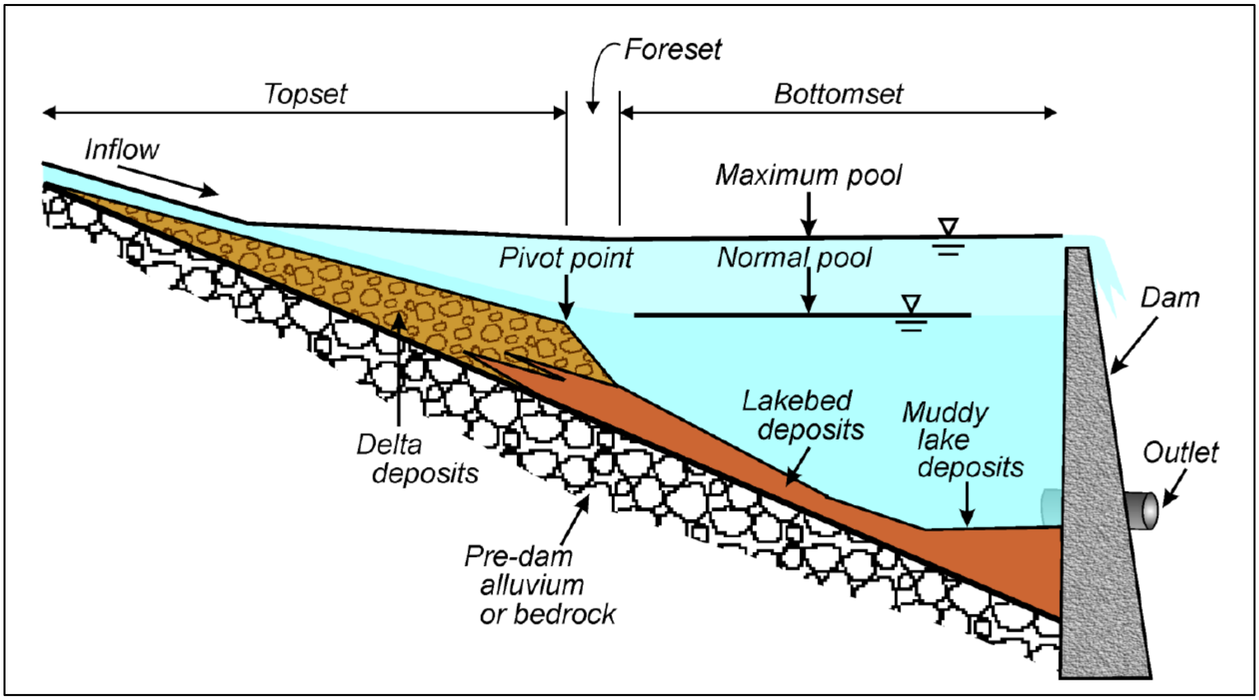



**Figure 3-104. Reservoir Sediment Profile with Delta and Lakebed Sediment Deposits**

Note: Reproduced with permission from Randle and Bountry (2017) after Morris and Fan (1997).

### Region A – Libby Dam: Head of Reservoir Sediment Mobilization

The focal point for deposition within the Libby reservoir (Lake Koocanusa) depends on the minimum drawdown elevation in the spring before the spring freshet (when 90 percent of the annual sediment load is mobilized). Since the early 2000s, the minimum pool elevation has ranged from a low of about 2,370 to a high of 2,420 feet NGVD29 (2,374 to 2,424 feet NAVD88) in elevation, which correlates to minimum lake backwater extent of RM 280 (near Kragmont, British Columbia) to RM 300 (4 miles downstream from Wardner, British Columbia). The maximum pool elevation (2,459 feet NGVD29 [2,463 feet NAVD88]) can extend upstream of Wardner to the Bull River confluence. Thus, Kootenai(y) River sedimentation (sand and gravel) in Lake Koocanusa is likely concentrated between Wardner and the Kootenai(y) and Tobacco River confluence, given that these locations correspond with the maximum and minimum reservoir elevations. Fine sediment is likely depositing throughout the reservoir but is focused primarily in the deeper portions of the reservoir near the dam.

### Region A – Hungry Horse: Head of Reservoir Sediment Mobilization

Little information is available regarding sedimentation in Hungry Horse Reservoir because of a lack of sediment load data and limited bathymetric survey. A recent bathymetric survey is available from 2018 that provides a longitudinal profile of Hungry Horse Reservoir with more detailed survey for the forebay extending about 0.5 mile upstream of the dam (Collins 2020). There are no large tributaries entering this reach as the reach is closely paralleled by the Swan Range to the west and the Flathead Range to the east. The majority of flow into the reservoir is from the upper South Fork Flathead River. One of the larger tributaries entering the reservoir, Sullivan Creek, has mean annual flows on the order of a few hundred cubic feet per second (U.S. Geological Survey [USGS] Gage 12361000). The drainage basin is almost all within U.S. Forest Service land management areas that were historically logged. Based on historical survey contours of unknown date (provided by Reclamation Pacific Northwest Regional Office, Boise, Idaho), the minimum pool elevation of 3,426 feet NGVD29 (3,430 feet NAVD88) has a backwater extent near RM 32 and the maximum pool elevation of 3,560 feet NGVD29 (3,564 feet NAVD88) extends another 9 miles to RM 41. A sediment delta is visible on a September 23, 2003, aerial photograph of the area between RM 38 and at least RM 41. The delta likely extends farther upstream. The reservoir delta is currently expected to be eroded and mobilized farther downstream in the reservoir during drawdown and would be expected to continue in No Action Alternative conditions.

**Region A – Albeni Falls: Head of Reservoir Sediment Mobilization**

The downstream control point of Lake Pend Oreille is Albeni Falls Dam, although there is a natural restriction near Dover, Idaho at RM 113—roughly 24 miles upstream of the dam—that can control flow based on lake elevation (velocities in the dam forebay channel can be “river-like” during high flow conditions). The water surface elevation of the lake may be 6 to 10 feet higher than that of the forebay due to the natural channel restriction at the lake outlet. The head of the reservoir is effectively the 4-mile-long Clark Fork River Delta, including the mouth of Lightning Creek. Lake level influences the velocity, depth, and general hydraulic conditions up to about a mile above Lightning Creek.

Rain-on-snow events and spring runoff have the potential to move tremendous amounts of bed load in tributaries of the Clark Fork River, but especially in the Lightning Creek drainage. A large alluvial gravel deposit has developed in the mainstem of the Clark Fork River in the floodplain of Lightning Creek, just upstream of the Clark Fork River Delta. The gravel bar includes a layer of gravels and sands deposited in the area by Lake Missoula, but now also hosts the thick gravel fragments and coarse cobbles of the Lightning Creek alluvial deposit.

The Lake Pend Oreille delta is composed of fine-grain sediments deposited in slackwater by the low-gradient Clark Fork River. The delta has likely been depositing since its formation, but the process likely accelerated following completion of the dam. The reduction in available sediment bedload within the Clark Fork River following completion of the upstream dams (Cabinet Gorge and Noxon Rapids) has also likely contributed. The bedload coming out of Lightning Creek is relatively high and dominantly comprised of large gravels and cobbles which ultimately settle at the Clark Fork River confluence due to the abrupt decrease in gradient between the creek and river.

**Region B – Grand Coulee: Head of Reservoir Sediment Mobilization**

Much of the sediment that would enter this reach from upstream is trapped by reservoirs in Canada, including behind four large hydroelectric dams. The reach of the Columbia River between the U.S.-Canada border and Grand Coulee Dam is naturally a bedrock-controlled river, lacking a thick alluvial cover (Whetten, Kelley, and Hanson 1969).

The mainstem Columbia River profile measured in 2010 and 2011 includes numerous pools between the U.S.-Canada border and Grand Coulee Dam that range in depth from 20 to more than 100 feet. The first 40 miles upstream of the dam contain several scour pools 30 to 40 feet deeper than the typical reservoir bottom, which indicates sediment supply has not been large enough to fill in the pools. The maximum reservoir pool extends upstream approximately 150 miles from the dam at RM 596 to about RM 746 based on 2010 topography. The minimum pool extends 121 miles upstream from the dam to about RM 717. Any sediment delta present between RM 717 and RM 746 could be eroded during reservoir drawdown operations. However, in this reach there was no sediment delta present, and several pools persist that are tens of feet deep, indicating sediment deposits are likely limited to partially filling pools and on floodplains when inundated at higher reservoir elevations. Two of the largest pools are more than 140 feet deep located near the confluences of the Columbia River with Onion Creek (RM 733.6) and the Kettle River (RM 709). The persistence of the deep pools means that either there are fast velocities along the reservoir bottom at these locations or the reservoir sedimentation rates are slow.

Sediment deltas can also form where tributaries enter the backwater from Lake Roosevelt. The first major tributary upstream of the dam is the Sanpoil River (RM 615) where Lake Roosevelt inundates about 9 miles of the tributary at full pool. The difference between maximum and minimum pool is 2 miles long where there is potential to mobilize any sediment deposited from the Sanpoil River Basin. Within Lake Roosevelt, the largest tributary is the Spokane River (total drainage area of 6,750 square miles), which begins at the outlet of Lake Coeur d'Alene, Idaho, and enters the Columbia River at RM 640 about 44 miles upstream of Grand Coulee Dam. The Spokane River contributes the largest amounts of suspended sediment to Lake Roosevelt (Whetten, Kelley, and Hanson 1969), but coarse sediment contributions that would tend to form a sediment delta are limited. Seven hydroelectric dams have been constructed on the mainstem Spokane River between 1890 and 1922 (Northwest Power and Conservation Council [NW Council] 2019c). Based on topographic intersection of reservoir pool elevations measured in 1974 (5-foot contours), the backwater from Lake Roosevelt extends about 18.5 miles upstream at minimum pool and 32 miles upstream at full pool (Ferrari 2012). Aerial photography from 1936 (after construction of the seven Spokane River dams) and recent aerial photography (1992 to 2017) do not show any exposed sediment delta downstream of Little Falls Dam. Further, the 2010–2011 survey measured several scour pools around 20 feet in depth (Ferrari 2012). The lack of visible sediment delta may be due to limited sediment supply due to trapping in upstream Lake Coeur d'Alene and behind the seven dams. There are several landslides along the Lake Roosevelt Arm of the Spokane River. A major landslide deposited more than 60 feet of eroded material above the original river channel area at RM 3.7. However, the landslide deposit is 40 feet below the minimum pool so it would not be expected to have any mobilization due to reservoir drawdown.

Lake Roosevelt creates about a 1.5-mile backwater up the Colville River, which enters the Columbia River near RM 702.4. The difference in maximum and minimum pool exposes about 1 mile of river that could create a sediment delta subject to erosion during reservoir drawdown. A larger tributary is the Kettle River, which enters near RM 709 on the mainstem Columbia River.

The 2010–2011 survey went about 3.5 river miles upstream on Kettle River near Kettle Falls. The maximum pool extends about 8 miles upstream on the Kettle River, and the minimum pool drops all the way to the Kettle River confluence with the Columbia River. Reservoir drawdown does have the potential to mobilize any deposited sediment from Kettle River incoming sediment loads. Upstream of Kettle Falls the reservoir does not create a substantial backwater pool in any tributaries.

Since the late 1800s, large amounts of slag have been released into the upper Columbia River from an upstream smelter operation. Because Lake Roosevelt has a high sediment trapping efficiency, much of the incoming slag has been retained within Lake Roosevelt, particularly in the upstream reaches (Teck 2017). As a result, bed and bank sediments in Lake Roosevelt contain elevated metals.

**Region C – Dworshak: Head of Reservoir Sediment Mobilization**

Dworshak Reservoir lies within narrow, steep canyons of the North Fork Clearwater River. Dworshak Dam traps sediment from 26 percent of the Clearwater River drainage basin (which is 2 percent of the Snake River drainage area). The reservoir extends approximately 51 miles upstream of the dam at full pool elevation. The drainage area upstream of the dam is topographically rugged, densely timbered, sparsely populated, and largely undeveloped with a total area of approximately 2,440 square miles (Corps 1986). The reservoir is drawn down during the winter to provide storage space for FRM.

Note that Dworshak Reservoir is the only reservoir in Region C operated for storage; the remaining reservoirs in Region C are run-of-river reservoirs. Sediment mobilization at the head of run-of-river reservoirs was computed separately via the "Potential for Bed Material Change Metric." Discussion of the head of reservoir sedimentation for Lower Granite Reservoir is presented in Section 3.3.2.4, below.

**Region D – John Day: Head of Reservoir Sediment Mobilization**

Unlike the other CRS storage reservoirs, John Day was constructed with navigation as a primary purpose. The project provides for minimum depth of 15 feet of water between John Day and McNary Dams. Due to this design requirement, and sediment trapping in upstream dams, there is no traditional head of reservoir delta or deposition occurring in the mainstem Columbia River in the John Day Reservoir.

**SEDIMENT TRAP EFFICIENCY**

All the reservoirs in the study area can trap a portion of the material that enters their pools, reducing the incoming sediment to downstream reservoirs. Trap efficiency is the proportion of inflowing sediment deposited in the reservoir relative to the total incoming sediment load. The trap efficiency is computed based on the ratio of reservoir storage volume to annual inflow. Reservoirs with high trap efficiency generally trap the coarse sediment in reservoir deltas, while a portion of the fine sediment can be transported through the reservoir and released downstream. The actual amount of sediment trapped is dependent not only on trap efficiency but also the incoming sediment load.

A trap efficiency less than 10 percent indicates very little sediment has accumulated in a reservoir, whereas a trap efficiency greater than 90 percent indicates potential for a large accumulation of reservoir sediment. John Day traps the least amount of sediment (44.9 percent) amongst the storage projects, which can be attributed to its small reservoir volume relative to the annual hydrograph. Albeni Falls (70.6 percent) and Grand Coulee (77.8 percent) trap approximately three-quarters of incoming sediment. Libby (90.7 percent), Hungry Horse (95.0 percent), and Dworshak (93.0 percent) have the highest sediment trap efficiencies.

**Region A – Libby Dam: Sediment Trap Efficiency**

Based on the sediment flux (total tons transported per year) measured in the 1960s near Libby Dam, it was estimated that 100,000 acre-feet of sediment would be trapped in Lake Koocanusa over a period of 100 years (Corps 1971). The volume of sediment that this represents over a 100-year period equates to about 2 percent of the 5-Maf total reservoir active flood control space (Corps 1971). By comparing the pre- and post-dam average annual sediment loads at the Libby and Copeland stations, the annual average sediment deposition can be estimated. Data confirms the 1971 estimate of 1,000 acre-feet per year and estimates that Libby Dam could accumulate about 31,000 acre-feet of sediment (suspended load, plus 10 percent for bedload) in a 30-year period.

**Region A – Hungry Horse Dam: Sediment Trap Efficiency**

While not much is known about reservoir sedimentation in Hungry Horse, it has a high trapping efficiency for sediment delivery from the 1,168-square-mile South Fork Flathead River catchment that prevents the majority of incoming sediment from going downstream past the dam to the main stem Flathead River.

**Region A – Albeni Falls Dam: Sediment Trap Efficiency**

Lake Pend Oreille, at more than 1,000 feet deep in some locations, acts as a natural sediment sink upstream of Albeni Falls Dam. The sediment trap efficiency is relatively high (70-plus percent), and it is responsible for reduced sediment supply conditions downstream along the lower Pend Oreille River.

**Region B – Grand Coulee Dam: Sediment Trap Efficiency**

The historical Columbia River channel within Lake Roosevelt is governed by the underlying bedrock because the riverbed does not have a deep layer of alluvium. Within the reservoir (Lake Roosevelt), substantial alluvial deposits are widely spaced and generally small in volume in both the riverine and lacustrine reaches of the reservoir (Ferrari 2012). The sediments that do accumulate in Lake Roosevelt consist of armored gravels between the U.S-Canada border and Onion Creek, which can become riverine during minimal pool conditions. Farther downstream, the river bed is primarily silt and clay in the middle and lower Lake Roosevelt (lacustrine) reaches (Whetten, Kelley, and Hanson 1969; Windward Environmental LLC 2017).

**Region C – Dworshak Dam: Sediment Trap Efficiency**

Sediment range lines have been surveyed in Dworshak Reservoir to measure sediment deposition, but the survey measurements are not reported here because the accuracy could not be verified; Dworshak Reservoir can exceed 600 feet in depth and is thermally stratified, making precise acoustic measurements highly sensitive to depth-varying calibration of the speed of sound. The Dworshak water control manual (Corps 1986) estimated an average annual sediment load on the order of 300 acre-feet per year, based on measurements of other streams in the region. Since the time of that estimate, limited sediment load measurements have been taken on the North Fork Clearwater River upstream of Dworshak and on two tributaries of the South Fork Clearwater River, which seem to support the argument made in the water control manual that the north fork is like other streams in the region. However, these measurements were taken during the spring season, and therefore would not have included mass wasting during large winter floods, which have the potential to exceed spring sediment loads. The estimate provided in the water control manual is higher than current sediment load estimates for the entire Clearwater River and is the only available estimate at this time. If the 300 acre-feet estimate is reasonable, it could take more than 2,500 years to accumulate a volume of sediment equal to the dead storage space in Dworshak Reservoir. However, this is an order of magnitude estimate and could therefore be conservatively reported as 250 to 2,500 years. In either case, the sediment load appears to be relatively small compared to the storage volume.

**Region D – John Day Dam: Sediment Trap Efficiency**

The most recent assessment of sediment deposition and bed material composition in the John Day Reservoir was completed by USGS (Cross and Twichell 2004). Geophysical survey data collected in 2000 and ground-validation data collected in 2000 and 2002 revealed that reservoir had lost approximately 0.2 percent of its volume since construction. Data analysis indicated that the reservoir bottom consists of 23 percent exposed basalt, 5 percent boulders, 9 percent fine-grained sediment with an estimated thickness of 20 inches, and 53 percent shallow discontinuous veneer of fine-grained sediment. This thin veneer covers historical bars, gravel beds, alluvial fans, and other unconsolidated deposits. The upstream-most 12.5 to 15.5 miles of reservoir, representing 10 percent of the total reservoir floor, showed gravel beds completely free of fine sediment.

**SHORELINE EXPOSURE**

Wave erosion, reservoir currents, freeze-thaw, reservoir drawdown, and other processes can result in shoreline erosion of bank sediments along the reservoir margins.

**Region A – Libby Dam: Shoreline Exposure**

During the design of Libby Dam, the Corps assumed that far less sediment would enter the reservoir from mass wasting and shoreline erosion than from the river itself (Corps 1971). Corps review of available aerial imagery showed that extensive shallow landslides along the 224-mile-long shoreline has occurred around the reservoir and that few large slides were evident. No subsequent estimates of reservoir sedimentation were available to assess if the amount of shoreline erosion that has occurred since the construction of Libby Dam is in line with predictions made during earlier design efforts. It is thought that in the first decades after reservoir filling, reservoir erosion rates were likely higher than under current conditions because more than four decades have elapsed since construction allowing for the reservoir side-slopes to erode back to stable conditions.

**Region A – Hungry Horse Dam: Shoreline Exposure**

Hungry Horse Reservoir has approximately 175 miles of shoreline with little available documentation on shoreline erosion. Most of the surrounding landscape contains forested hillslopes, but areas subject to reservoir drawdown may experience erosion. A prior Columbia River System Operation Review EIS (DOE, Corps, Reclamation 1995) noted that "Hungry Horse Reservoir exhibits significant shoreline erosion in its upstream reaches, as well as several large, active landslides." The magnitude of erosion is not known.

**Region A – Albeni Falls Dam: Shoreline Exposure**

Lake Pend Oreille has a seasonal variable operating range of about 11 feet as regulated by Albeni Falls Dam, which has caused lateral shoreline erosion of the delta at a rate of about 5 to 8 feet per year for the last 50-plus years (Clark Fork Delta Restoration 2018). The Clark Fork River delta at the east end of the lake is not the only area around Lake Pend Oreille with eroding shorelines. Receding protective and stabilizing shorelines and islands at the mouths of streams and rivers have seen accelerated erosion caused by wave action, landslides, and river flows. Additional sites in the subbasin where ongoing erosion is of concern include the Pack River Delta, Strong's Island, and the mouths of Priest River, Hoodoo Creek, Hornby Creek, and Carr Creek (Idaho Department of Environmental Quality [IDEQ] 2007). Overall, the riverbank conditions of the Pend Oreille River above Albeni Falls are highly susceptible to erosion where the banks do not consist of bedrock or large boulders (Tri-State Water Quality Council 2005).

**Region B – Grand Coulee Dam: Shoreline Exposure**

Landslides are an important source of sediment along the Lake Roosevelt shoreline. Some landslides along the Columbia River within Lake Roosevelt existed before the construction of Grand Coulee Dam and are a few hundred to a few thousand years old (Pardee 1918; Kiver and Stradling 1995); other landslides appear to have been associated with destabilization of the landscape during glaciation (Flint and Irwin 1939; Jones et al. 1961). More than 500 landslides also formed along the shoreline of Lake Roosevelt in response to the filling of the reservoir and fluctuating water level (Cox et al. 2005).

**Region C – Dworshak Dam: Shoreline Exposure**

Dworshak Reservoir's shoreline is approximately 175 miles at full pool (Corps 1986). The widest sections of the reservoir are in the lower one-third of its length, where the widths range generally from about 0.5 to 1 mile, with the widest point being nearly 2 miles. The upper two-thirds of the reservoir is much narrower, ranging mostly between 1,000 and 2,000 feet. The lake water surface elevation can fluctuate up to 155 feet due to Dworshak Dam flood risk operations, but during lower risk years, the water surface is only drawn down 80 feet below full pool. Bank erosion or sloughing resulting from fluctuations in pool elevation is not known to be a serious issue.

**Region D – John Day Dam: Shoreline Exposure**

There are deep-seated landslides in the vicinity of John Day Dam and reservoir. Most mass wasting has occurred on the Washington shore. A landslide on the Washington shore was reactivated during dam construction but appears stable now. Most of the shoreline is not being significantly eroded, and riprap protection seems to be adequate for lower pool operation (Gustafson 1992).

#### *3.3.2.4 Run-of-River Reservoirs and Free-Flowing Reaches*

Run-of-river reservoirs and free-flowing reaches include all the river reaches downstream of CRS storage projects. Run-of-river reservoirs are formed by dams that are operated to discharge water downstream at rates that generally match the upstream inflows. The effect on river discharge from dam operations is generally smaller for run-of-river reservoirs than storage reservoirs. Bonneville Dam is an example of a run-of-river project that operates in a small range of pool elevations for daily or weekly hydropower purposes but does not attempt to store water for release in later seasons. There are nine CRS run-of-river reservoirs. Region B includes Chief Joseph at RM 545.7. Region C includes Lower Granite (RM 430.9), Little Goose (RM 393.8), Lower Monumental (RM 365.0), and Ice Harbor (RM 333.4) on the Lower Snake River. Region D on the Lower Columbia River includes McNary (RM 291.0), John Day (RM 216.6), The Dalles (RM 192.0), and Bonneville Dam (RM 145.7). Note that John Day Dam generally operates as a run-of-river project even though there is a small amount of storage, and thus is included in both categories. Five non-CRS run-of-river reservoirs exist in Region A and another five exist in Region B.

Free-flowing reaches are portions of the river that are not influenced by the backwater of a downstream reservoir. Free-flowing reaches experience altered hydrology where upstream dam operations have an influence on changing river discharge. The altered hydrology can affect floodplain connectivity, river morphology, and sediment transport capacity. Free-flowing reaches in Region A include the Kootenai River between Libby Dam and Bonners Ferry, Idaho, the Flathead River downstream of Hungry Horse Dam and upstream of Flathead Lake, and the Clark Fork River between SKQ Dam and Thompson Falls Reservoir. Other notable free-flowing reaches in the study area include the Northport Reach of the Columbia River upstream of Kettle Falls and the Hanford Reach of the Columbia River downstream of Priest Rapids Dam (Region

B), the Clearwater River between Dworshak Dam and Lower Granite Reservoir (Region C), and the tidal Columbia River downstream of Bonneville Dam (downstream Region D).

**SEDIMENT TRANSPORT AND SUPPLY.**

Unlike the large storage projects, nearly all the run-of-river reservoirs have a small volume of water in their pools relative to the volume of annual water flow. This results in lower trapping efficiencies than the large storage projects. In addition to the decreased ability of the run-of river reservoirs to trap sediment, the upstream sediment load is reduced because of upstream reservoirs.

Free-flowing reaches are operating in a reduced sediment environment from their historical unregulated (pre-1930s) condition because of cumulative trapping of sediment in upstream reservoirs. These reaches commonly pass the reduced incoming sediment load and have developed coarsened bed conditions, some of which are naturally armored against erosion.

Bed-material load consisting of sands and gravels entering run-of-river reservoirs and free-flowing reaches from tributaries and other processes such as localized erosion can deposit on the beds and be permanently stored in the system. Given the variability in size and nature of tributaries flowing into the study area, the amount of sediment delivered and stored at each tributary may be negligibly small or quite sizable. The Salmon River (via the Snake River) and Clearwater River sediment delivery to Lower Granite Reservoir on the Snake River is an example of a large tributary sediment supply that deposits a large volume of sediment annually.

**Region A – Kootenai River Sediment**

Glaciation on the Kootenai River during the ice ages is responsible for carving deep valleys now occupied by lakes and rivers over long and short time periods, storing large quantities of unconsolidated sediment in the basin valleys. When the ice sheet and associated glacial lake receded, the steep, rejuvenated rivers and streams widened their valleys, transporting large volumes of sediment downstream. In some places, the Kootenai River has cut through the glacial sediments into the underlying bedrock. Bedrock is exposed in the riverbed near the Fisher River, in the Kootenai Falls area, and near Troy, Montana. It is also exposed in riverbanks and bottomlands near Bonners Ferry, Idaho.

The bedrock sill at the outlet of the West Arm of Kootenay Lake arrested down-cutting. It is likely that post-glacial Kootenay Lake originally extended south along the Purcell Trench nearly to Bonners Ferry, but it was gradually filled with hundreds of feet of fine sediment eroded from up valley so that the lake was gradually converted into a floodplain (Alden 1953).

The Kootenai River downstream of Libby Dam is free flowing for approximately 61 miles, after which it becomes progressively less able to transport sediment due to backwater influences from Kootenay Lake located north of the U.S.-Canada border. In a 6-mile reach known as the “Braided Reach” immediately above Bonners Ferry, the river can pass sediment sizes up to gravels. Downstream of Bonners Ferry, sand silt and clay become the dominant material in transport with little gravel passing into the downstream reach known as the "Meander Reach." Due to the Kootenay Lake backwater, the 45-mile long Meander Reach is the least-efficient reach at passing sediment in U.S. waters below Kootenai Falls, passing fine sand and smaller grain sizes downstream.

Below Libby Dam, tributaries supply large quantities of gravel- and cobble-sized materials at rates greater than the rates the mainstem river can erode them, resulting in the formation of alluvial fan deposits. Because these locations constrict the river, they tend to transport all but the largest-sized sediment that enter from upstream. The largest-sized sediment from steeper tributaries is often found in tributary fans that persist despite high flows from the river (e.g., at the Fisher River, Yaak River, and Boulder Creek confluences). Cobble, gravel, and sand sized sediments that make it into the reaches upstream of Bonners Ferry can be transported by the river downstream to the Braided Reach; however, much of this material is too large to be transported very far downstream. Thus, the Braided Reach is a sink for gravel and coarser-sized sediment supplied by the river upstream.

Downstream of Libby Dam to Bonners Ferry, the percentage of sand within the exposed bars increases with distance from the dam because of unregulated tributary inputs. The percentage of the bed composed of sand increases dramatically in the critical Kootenai River white sturgeon spawning reach, where the Braided Reach transitions into the Meander Reach (Barton, McDonald, and Nelson 2009; Fosness and Williams 2009; McDonald et al. 2010). Previous research (Barton, McDonald, and Nelson 2009; McDonald et al. 2010) has determined that the Kootenai River white sturgeon spawning reach substrate is sand dominated now, but that this is an artifact of the reduction in peak discharges as the pre-dam high flows were routinely capable of scouring sand and exposing coarser lag deposits of gravel and cobble suitable for spawning. The researchers found that the post-dam hydrologic regime, under the highest post-dam flows, can still scour sand from these spawning areas (Fosness and Williams 2009; McDonald et al. 2010), but this occurs much less frequently than under pre-dam conditions.

**Region A – Flathead, Clark Fork, and Pend Oreille Rivers Sediment**

Even before the completion of SKQ Dam, the naturally occurring Flathead Lake and delta functioned as a sediment trap for the downstream Flathead River. Joyce (1980) concluded that Flathead Lake had been accumulating roughly 0.55 inches per year of sediment since the 1964 flood of record. The largest sources of sediment within the study reach exist in the thick Quaternary (a recent period of geologic time spanning from 2.58 million years ago until today that was marked by the advance and retreat of glaciations, greatly sculpting the landscape morphology) deposits within Flathead Valley, upstream of Flathead Lake. Shorelines of Flathead Lake provide an additional source of sediment; however, this source is not as substantial, as Flathead Lake receives more than 90 percent of its sediment from the Flathead River (Moore, Jiwan, and Murray 1982). Sediment from upstream and eroded from Flathead Lake is likely trapped within the lake, rather than traveling downstream.

Downstream of the Hungry Horse Reservoir in the South Fork Flathead, Alden (1953) notes that till (glacially transported sediment that is typically poorly sorted) and gravel have been largely eroded from many locations, allowing the river to cut bedrock gorges, leaving terraces of Quaternary gravels bordering the river in some locations.

The Flathead River below the confluence with the South Fork Flathead River is an active, anastomosing river (a river planform type where multiple channels are separated by stable mid-channel islands commonly associated with flood regimes) within a massive valley. The undammed North and Middle Forks of the Flathead River are a sediment source, and large amounts of sediment and wood are associated with a large peak flow. Deposition of debris that fills a channel, or flood flows that occupy alternative channel routes with steeper paths, are both potential risks for channel avulsions (the process of a river channel changing its planform by abandoning its previous path in favor of another channel path; this can result in the creation of a new channel or the shifting of flow to a side channel or previously abandoned channel path). In part because Flathead Lake controls the river's base level, there has also been substantial re-working, rather than removal, of these deposits within the basin (Smith 2004).

The natural sink of the deep Flathead Lake and the regulated operations of SKQ Dam make for a sediment-starved lower Flathead River. Downstream of SKQ Dam, Lake Pend Oreille is an efficient natural sediment sink in the Flathead, Clark Fork, and Pend Oreille Rivers. Between SKQ Dam and Albeni Falls, Noxon Rapids Dam traps the highest percentage of inflowing sediment. Downstream of Albeni Falls, the Slate Creek to Boundary Dam reach traps the highest percentage of inflowing sediment.

The Clark Fork River subbasin is prone to rapid runoff events; however, system wide flow regulation has curtailed this phenomenon. Glacial fluvial deposits are present in the valley, river banks, and on mountainside slopes. The highly erosive sediments have worked their way through the Clark Fork River System in infrequent flood pulses, such as 1948 and 1997, while conversely getting trapped behind hydroelectric dam projects during low- to moderate-hydrologic years.

Following the construction of Albeni Falls Dam, the lake has been held at a higher-than-natural condition and operated over a range of 11 feet. While the Clark Fork River contributes approximately 92 percent of the annual inflow to Lake Pend Oreille (IDEQ 2007), most of the annual suspended sediment load is contributed from Lightning Creek. Lightning Creek gradient and channel incision make for fairly unstable banks that are prone to naturally occurring mass failures (U.S. Department of Agriculture [USDA] 2015). A recent sediment model estimated a delivery to the Clark Fork River via Lightning Creek of more than 4,100 tons of sediment per year (IDEQ 2007). The majority of large gravels, cobbles, and boulders it transports to the river settle at the confluence because of the extreme decrease in grade from Lighting Creek to the river. The Clark Fork River Delta is an important sediment depositional zone.

The Pend Oreille River channel substrate above Albeni Falls Dam is dominated by granitic type sands and silt with areas of embedded heavy woody organic debris that is derived from catchments below Cabinet Gorge Dam. Although some recent substrate sampling work was somewhat limited in scope, very little gravel was found on the river bottom, and the gravel that was encountered was buried within sand and silt.

Box Canyon Dam likely traps coarse sediments brought in by tributaries or bank erosion. Downstream of Box Canyon Dam, the reservoir behind Boundary Dam becomes a substantial sink of bed material and some suspended sediment. Clay deposits appear in the Boundary Dam forebay, though most all of it passes through the project, according to a sediment model built for 2009 sedimentation study (Fullerton et al. 2009). Approximately one-quarter of the silt is trapped in the reservoir, and nearly 100 percent of the bed material load is trapped. The clay fractions represent on average approximately 20 percent of the forebay samples, with silt comprising most of the remaining material.

**Region B – Middle Columbia River Sediment**

Below Grand Coulee Dam, tributaries are an important source of sediment and alluvial fans exist near the junctions with many tributaries. Landslides also exists along shorelines below Grand Coulee Dam, providing sediment to these reaches. Suspended sediment concentrations in the upper Columbia River are typically low; the greatest amounts of suspended sediment are sourced from the Okanogan River. During high flow events, suspended sediment can pass through structures to downstream reaches; otherwise, suspended sediment is trapped by reservoirs.

From Grand Coulee Dam to Priest Rapids Dam, bed material is dominated by thin deposits of gravel and sand over bedrock. Generally, the grain size of reservoir deposits increases with distance upstream of the dams in each reservoir (Kelley and Whetten 1961; Whetten, Kelley, and Hanson 1969).

Below Priest Rapids Dam, the free-flowing Hanford Reach composition is largely sand, gravel, and cobbles up to 8 inches in diameter, with small fractions of silt and clay in lower-velocity deposition areas (Jamison 1982).

**Region C – Lower Snake River Sediment**

Sediment yield to the lower Snake River is derived from three major basins: upper Snake River, Clearwater River, and Salmon River. Sediment contributions to the Snake River from upstream of Hells Canyon Dam are effectively trapped by the Hells Canyon Complex (Hells Canyon Dam, along with upstream Oxbow and Brownlee Dams), and are essentially small enough to be considered negligible. The North Fork of the Clearwater River is regulated by Dworshak Dam, which retains all sediment upstream. The remaining Clearwater Tributaries (Lochsa, Selway, South Fork Clearwater, Potlatch River, and Lapwai Creek) comprise about 10 percent of the lower Snake River sediment load on average. Downstream of Hells Canyon Dam, the Salmon River sediment yield averages about two-thirds of the lower Snake River sediment load. Downstream of these confluences, the Snake River at Anatone, Washington, comprises about 90 percent of the sediment load to the lower Snake River (PSMP, Corps 2014c).

The deep run-of-river reservoirs of the four lower Snake River dams have the least ability to transport sediment of all reaches between the Columbia River and Dworshak Dam. While the four reservoirs have similar characteristics, the upstream reservoir, Lower Granite, receives a substantially larger sediment load originating in the free-flowing Salmon River, upper Clearwater River, and other smaller tributaries. Lower Granite only passes clay and silt-sized material up to coarse silt, which is largely capable of passing through the lower three Snake River Dams to McNary Reservoir.

Lower Granite Reservoir continues to be a depositional zone for Clearwater and Snake River sands and silts. Coarse sediment (median particle diameter by mass, $d_{50}$, of medium sand) settles out first near the upstream end of the reservoir, followed by finer sediment moving downstream ($d_{50}$ approaching very fine silt at Lower Granite Dam). Suspended sediments passing Lower Granite Dam largely pass through the remainder of the downstream Snake River dams. Bed material in the lower three reservoirs range from a $d_{50}$ of medium sand to fine silt with Ice Harbor Reservoir sediment being coarsest and Lower Monumental Reservoir sediment being finest. Sediment deposition in the Snake River is managed per the Lower Snake River Programmatic Sediment Management Plan (PSMP) (Corps 2014c). The PSMP is the sediment management strategy for the lower Snake River system extending from the Snake River confluence with the Columbia River to the upstream limits of Lower Granite Reservoir, including the lower portion of the Clearwater River. The management measures fall within four general categories: dredging and dredged material management, structural management, system management, and upland sediment reduction. The PSMP does not attempt to address all sediment deposition in the lower Snake River. It addresses only sediment that interferes with existing authorized project purposes of the lower Snake River Projects.

***Region C – Lower Snake River Navigation Sedimentation***

Sediment accumulates in areas where it impacts navigation or other authorized purposes in the lower Snake River System. Sediment management is conducted in these areas in conformance with the PSMP. The PSMP is the Corps' adaptive management plan for maintenance actions managing sediment accumulation in the lower Snake River Projects (Corps 2014c). According to the PSMP, "Approximately 80 percent of the volume of material historically dredged from the LSRP [lower Snake River Projects] system has come from Lower Granite Reservoir." The primary area of concern for recurring immediate actions is near the confluence of the Snake and Clearwater Rivers, which is at the upstream end of the Lower Granite Reservoir. The navigation channel can be dredged on an as-needed basis to the federally authorized depth of 14 feet at MOP. The dredged material may be placed in-water (sometimes to create beneficial shallow-water habitat for juvenile salmonids and other species) or upland.

**Region D – Lower Columbia River Sediment**

Bed material in the Columbia River at the Snake River confluence has an observed $d_{50}$ of fine sand. The bed material becomes finer going downstream with a $d_{50}$ of medium silt in the 25 miles of reservoir immediately upstream of McNary Dam. The McNary Reservoir receives sediment from multiple tributaries including the mainstem Columbia, Yakima, Snake, and Walla Walla Rivers. Sand-sized and larger sediments, as well as some silts, deposit in the reservoir below the Snake River confluence with the Columbia River, and only clays and silts are capable of passing McNary Dam.

Downstream of McNary, the lower John Day Reservoir has the lowest ability of any subreach to transport coarse sediment. While John Day Dam is a CRS storage project, the reservoir more resembles the mainstem Columbia River run-of-river reservoirs in how upstream sediment loads are supplied and transported through. Despite John Day's low ability to transport sediment relative to the downstream reaches, the upstream sediment supply is primarily silt, which largely passes through John Day Reservoir. The lower Columbia Dams do effectively trap the coarse Cascade Range tributary sediments with only medium to fine silt and clay passing Bonneville Dam. Sediments capable of passing Bonneville Dam transport all the way to the Columbia River estuary and Continental Shelf.

Bed material sediments (sand and gravel) in the Columbia River reservoirs below McNary tend to persist in these areas. The Bonneville Reservoir retains a large volume of relict fine sand that was likely deposited behind the massive Bridge of the Gods landslide 550 years ago. Episodic high sediment loading from Cascade Range tributaries will continue to provide coarse material that deposits as bed material at tributary confluences with the Columbia. The reservoirs below McNary hydraulically trap some suspended sediment passing McNary Dam and from tributary inflow directly to the reservoirs, resulting in shallow silt deposits on coarser bed material. Below Bonneville Dam, deep historical bed material deposits along with Cascade Range tributary inflow supply a bed composed primarily of medium to fine sand. Large sand waves can form in all sections of the tidal reach below Bonneville Dam, indicating active reworking and transport of bed material within the reach.

***Region D – Lower Columbia River Navigation Channel Dredging Volumes***

The current 43-foot-deep Lower Columbia River Federal Navigation Channel (LCR FNC) was authorized by Section 101(b)(13) of the Water Resources Development Act of 1999 (Public Law 106-53), and Division H, Section 123 of the Consolidated Appropriations Act of 2004 (Public Law 108-199), and constructed from 2005 to 2010. The previously authorized LCR FNC was authorized to a shallower 40-foot-deep channel. The current channel is:

- 43 feet deep and 600 feet wide from RM 3.0 to 101.4
- 43 feet deep and 500 feet wide from RM 101.4 to 105.5
- 43 feet deep and 400 feet wide in the downstream 1.5 miles of Oregon Slough
- 35 feet deep from RM 105.5 to 106.5

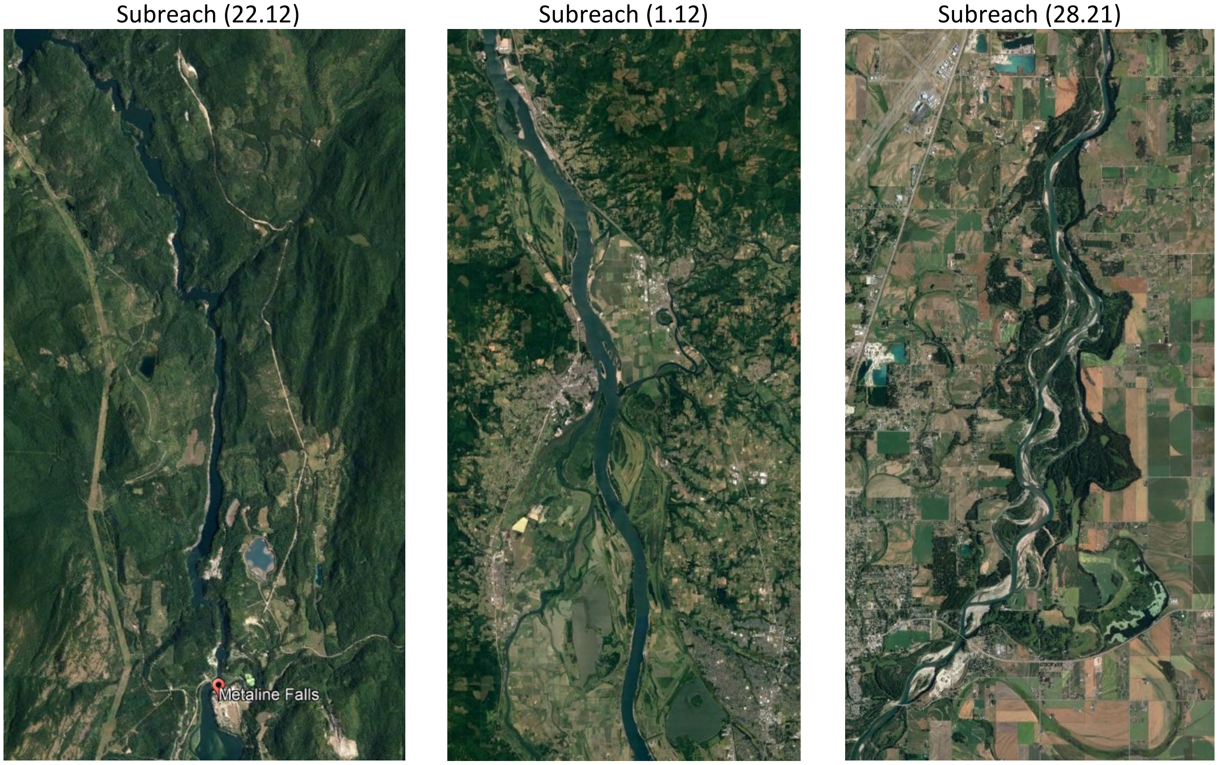
The rapidly changing and uncontrollable shoaling (shallow) conditions within the LCR FNC require continual maintenance dredging. Segments of the LCR FNC are dredged on an annual or semi-annual basis due to reoccurring shoals. Shoals require dredging depending on intensity and timing of flows and seasons. The Corps also relies on channel training features, including pile dikes, to scour sediments from the LCR FNC and thereby reduce the need for maintenance dredging over time. Present sedimentation processes require that the Corps annually remove 6 to 10 million cubic yards (MCY) of sand from the LCR FNC below Bonneville Dam. Dredged material is primarily placed in-water or adjacent to the LCR FNC, along the shoreline, and at upland sites, but the material can also be placed at designated ocean disposal and near-shore sites.

## RIVER MORPHOLOGY

The width to depth (W/D) ratio is a measure of bankfull (i.e., active channel) width to mean bankfull depth perpendicular to stream flow (Figure 3-105). High W/D ratios tend to reflect river reaches that have wide, connected floodplains or are geomorphologically complex, such as river confluences. In the Columbia River Basin, high W/D ratio reaches are typically free-flowing alluvial reaches like the Hanford Reach of the Columbia River or unique geomorphic features. An example of a unique feature is the Snake and Walla Walla River confluences with the Columbia River immediately upstream of the Wallula Gap where the Columbia River was carved wide by the Missoula Floods and is impounded by McNary Dam.

Low W/D ratios tend to indicate geologically or anthropogenically confined reaches with little floodplain connection and deeper channels that have high sediment transport potential. Within the area of analysis, low W/D ratio is typically due to natural valley confinement such as on the South Fork Flathead River immediately downstream of Hungry Horse Dam where the river flows in a deep mountain canyon. The majority of reaches in the study area exhibit a W/D ratio between 10 and 100 for annual peak flows.

| **Low** | **Moderate** | **High** |
|---|---|---|
| Pend Oreille River between Metalne Falls, Washington, and Slate Creek Subreach (22.12) | Columbia River between Willamette and Cowlitz Rivers Subreach (1.12) | Flathead River, Columbia Falls, Montana Subreach (28.21) |




| | | |
|---|---|---|
| Median W/D radio: 9, Interquartile range: 6–14 | Median W/D radio: 78 Interquartile range: 64–100 | Median W/D radio: 160 Interquartile range: 118–293 |

**Figure 3-105. River Planform Examples of Relatively Different Width to Depth Ratio Ranges Observed in the Columbia River System study area.**

**Region A – Kootenai River Morphology**

In the 26 river miles between Libby Dam and Kootenai Falls, median W/D ratios are moderate (68 to 78) with an interquartile range between 45 and 118. Downstream of Kootenai Falls, the river enters the 33-mile-long Canyon Reach with a median W/D ratio of 50 and an interquartile range between 29 and 74.

Relatively moderate to high W/D ratios occur in the active alluvial Braided Reach of the Kootenai River with an interquartile range between 70 and 200 and median around 90. This is a transitional reach from the steeper, confined upstream Canyon Reach (median W/D ratio around 50) to the flat-gradient expansive Meander Reach that enters Kootenay Lake. Despite the wide valley and high relative W/D ratio, the Braided Reach has experienced levee construction that confined the active valley by approximately 50 percent.

Low W/D ratios are observed downstream in the Meander Reach of the Kootenai River. Despite the expansive valley width due to its geologic history as a former embayment of the Glacial Kootenai Lake, the reach exhibits low W/D ratio with an interquartile range between 18 and 33 and a median around 23. Continuous levees on both banks have reduced the floodplain by 90 percent and confined the active valley by 66 percent. The moderately active channel has greater depths than the upstream Braided Reach, adding to the low W/D ratio.

**Region A – Flathead, Clark Fork, and Pend Oreille Rivers Morphology**

Within the Flathead, Clark Fork, and Pend Oreille Rivers below SKQ Dam, there is great variability in W/D ratios.

Between Hungry Horse and SKQ Dams, the upstream and downstream ends of the major reach have low W/D ratios while the middle reaches and Flathead Lake have high W/D ratios. Immediately downstream of Hungry Horse Dam the South Fork Flathead River has a single-thread stream channel in a narrow bedrock canyon resulting in low W/D ratio with a median less than 30. The Polson to SQK Dam reach is similarly a single-thread channel flowing in a narrow gorge cut through bedrock.

From the confluence of the South Fork Flathead River with the mainstem Flathead River downstream to Polson, the reaches exhibit high W/D ratios (median between 135 and 160). The reaches upstream of Flathead Lake are characterized by an anastomosing stream channel within a wide valley filled with thick unconsolidated deposits. Flathead Lake itself is simply immensely wide and not necessarily well represented by the W/D ratio metric as it is fundamentally a naturally formed lake.

The highest W/D ratios in Region A are seen at the Clark Fork River Delta (median around 85), which is the largest area of contiguous wetland complex in the Pend Oreille River System. The delta extends roughly 4 miles downriver from the town of Clark Fork, Idaho, and is roughly 3 miles wide where the delta meets Lake Pend Oreille. The Indian Creek to River Bend subreach below Albeni Falls Dam is another high W/D ratio reach with an interquartile range between

106 and 160 and a median near 132. The valley between the Selkirk Mountains to the east and the Kalispell Mountains to the west becomes wide at this point.

Reaches of low W/D ratios are seen throughout the Clark Fork River between Thompson Falls Dam and Cabinet Gorge Dam with median ratios between 17 and 38. This reach follows the Hope fault, which lies on the riverbed as a structural separation of the Cabinet and Bitterroot Mountains (USGS 1946). Near Cabinet Gorge, there are now vertical rock cliffs hundreds of feet high. Low W/D ratios are also present downstream of Box Canyon Dam between Metaline Falls and Boundary Dam with median ratios less than 10.

**Region B – Middle Columbia River Morphology**

Between Grand Coulee Dam and the U.S.-Canada border, there are four defined subreaches of the middle Columbia River spanning approximately 143 river miles. The three upstream-most subreaches constitute approximately 99 river miles upstream of the Spokane River confluence with median W/D ratios between 37 and 45 and an interquartile range between 26 and 77. The lower 44 river miles downstream of the Spokane River confluence comprise the lower Lake Roosevelt subreach with a median W/D ratio of 25 and an interquartile range between 19 and 34.

Downstream of Grand Coulee Dam to the Yakima River confluence there are two reaches that exhibit high W/D ratios. Within the Upper Wells Reservoir subreach, there is high variability of W/D ratios (interquartile range between 30 and 300) including a wide and shallow area near the Okanogan River confluence at Brewster, Washington. The second highest W/D ratio subreach extends from Lower Wanapum Reservoir downstream to Richland, Washington, with median W/D ratios between 90 and 100. Despite appearing as a continuously wide W/D zone, the river upstream of Priest Rapids Dam is impounded while the Hanford and Richland Reaches are free-flowing. The inundated width at the Wanapum and Priest Rapids projects is particularly wide relative to the depth of the reservoirs, resulting in the high W/D ratio. The free-flowing alluvial reaches downstream have bar and island complexes throughout. There are two Middle Columbia reaches that exhibit low W/D ratios. Chief Joseph Reservoir is narrowly confined in Columbia Plateau bedrock, particularly in the downstream portion of the reservoir with a median W/D ratio around 12. Low W/D ratios are also observed downstream in the Lower Rock Island Reservoir reach near the community of Wenatchee, Washington, with a median W/D ratio around 40 and the 25th percentile ratio near 20.

The Middle Columbia River from Grand Coulee Dam to the Yakima River confluence is extensively shaped by Ice Age outburst flooding. Below Grand Coulee, the Columbia River has an irregular channel with meanders that are narrowly confined by Columbia Plateau bedrock bluffs to Bridgeport, Washington. Downstream of Bridgeport, the Columbia River flows along the border between the Columbia Plateau and North Cascade province. The reach between Bridgeport and Priest Rapids Dam is a semi-confined channel separated by alluvial valleys. Below Priest Rapids Dam, the free-flowing alluvial Hanford Reach flows along the edge of Channeled Scabland.

**Region C – Clearwater and Lower Snake River Morphology**

The Clearwater and Lower Snake River reaches are cut deeply into the Columbia River Basalt Plain. In the lower subreach between Ice Harbor and McNary Reservoir confluence, the Snake River enters the downstream portions of the Channeled Scablands carved by Ice Age floods with a median W/D ratio around 130. The Ice Harbor Reservoir subreach is distinct in that there are localized areas of both relatively high and low W/D ratio zones intermittently occurring within the subreach with a median W/D ratio of around 50. This variability demonstrates the scale and complexity of the alternating slots, pools, and bars carved into the basalt plain by Ice Age events. Between Ice Harbor Dam and the Clearwater confluence near Lewiston, Idaho, the Snake River is more confined with median subreach W/D ratios between 30 and 70. While portions of the free-flowing Clearwater and Snake Rivers upstream of Lower Granite Reservoir are highly confined in a steep and deep valley, median W/D ratios range between 40 and 110.

**Region D – Lower Columbia River Morphology**

Similar to the Lower Snake River below Ice Harbor, the McNary Reservoir reach is cut deeply into the Columbia River Basalt Plain and occupies the downstream portions of the Channeled Scablands carved by Ice Age floods. In the McNary Reservoir area, the subreach between the Snake River confluence and Wallula is characterized by a relatively high W/D ratio with a median of nearly 500. This wide and shallow reach upstream of the bedrock basalt Wallula Gap was carved by the Missoula Floods and is impounded by McNary Dam. The alluvial Snake and Walla Walla River confluences with the Columbia River are both located in this subreach.

The Columbia River below McNary cuts a narrow sea-ward path through the Cascade Range before meeting the north end of the Willamette Valley. The Columbia River then passes through the Coast Range before flowing into the Pacific Ocean. Columbia River waters are affected by the tide upstream to Bonneville Dam. Prior to construction of the dam, the head of tide extended 3 miles further upstream to Cascade Falls near the town of Cascade Locks, Oregon, and the site of the historical Bridge of the Gods Landslide.

On the Columbia River below McNary Dam, there are three areas that exhibit high W/D ratios. The upstream most reach is the upper John Day Reservoir near the Blalock Islands where the valley is wide and the river flows through Quaternary deposits. Further downstream, below Bonneville Dam, in the area between Skamania and Vancouver, Washington, are free-flowing sand bed reaches at the downstream end of the Columbia River Gorge where the river meets the wide Willamette Valley. The most downstream zone is the Columbia River below the Cowlitz River, a zone that includes the wide and shallow tidal estuary.

Two Lower Columbia subreaches exhibit moderately low W/D ratios. Upstream is The Dalles Dam to Memaloose Island subreach where the Columbia River passes through a tightly confined bedrock slot downstream of the now inundated Celilo Falls with a median W/D ratio around 50. Downstream is the Cascade Falls to Bonneville Dam subreach which is confined from the north by remnants of the Bridge of the Gods Landslide with a median W/D ratio under 20.

### 3.3.3 Environmental Consequences

Environmental consequences related to river mechanics processes were evaluated in a comparative nature between a select MO and the baseline No Action Alternative. The general approach for evaluating system response for river mechanics was to use the stochastic daily output from the quantitative hydroregulation planning models as analysis inputs to compute a suite of seven quantitative metrics as described in Section 3.3.3.1, below. Note that in order to accurately represent spatiotemporal effects, the hydroregulation model analyses were applied using daily average values over the entire FCRPS basin and metrics presented herein are limited to the previously identified CRS projects. Due to a number of limitations associated with the H&H modeling process (see Appendix B), the baseline conditions established by the No Action Alternative results may not necessarily completely characterize the actualized conditions. More specifically, the daily average resolution of H&H results are limited in that sub-daily variability is not represented. The most sensitive parameter to sub-daily variability is expected to be reservoir operational stage which is used to compute energy grade slope and subsequently boundary shear stress, one of the primary inputs for sediment transport metrics. Nonetheless, considering the size of the study area and the stochastic methodology used, the No Action Alternative and MO results were deemed sufficiently representative to adequately describe the hydrology and hydraulics as required to establish a general baseline of the study area for trend and departure analysis.

Environmental consequence impacts are identified for each of seven river mechanics metrics based on thresholds of relative change (MO versus No Action Alternative) normalized to five levels (No Effect, Negligible, Minor, Moderate, and Major). To facilitate interpretation, the results for the estimated environmental consequences are presented in the following sections organized by each alternative and grouped by CRS project type (storage or run-of-river).

#### *3.3.3.1 Analysis Metrics*

Both quantitative and qualitative assessment methods were used to assess relative potential changes to river mechanics (sediment transport and geomorphology) for each MO. Seven quantitative metrics were developed to represent various physical characteristics and processes that could affect storage reservoirs, run-of-river reservoirs, and free-flowing reaches as enumerated below.

- Storage Project Metrics
  - Head of Reservoir Sediment Mobilization
  - Sediment Trap Efficiency
  - Shoreline Exposure
- Run-of-River Reservoirs and Free-Flowing Reach Metrics
  - Potential for Sediment Passing Reservoirs and Reaches
  - Potential for Bed Material Change

- Potential Change to Width to Depth Ratio
- Potential Changes to Navigation Channel Dredging Volumes

These seven scalar metrics are derived as deterministic calculations based on the H&H numerical modeling work (see Section 3.2.2.1) which established stochastic datasets that represent the system state of hydrology, hydroregulation, and riverine hydraulics. While dimensionally consistent, the geomorphic and sediment transport metrics are intended to provide a measure of relative change between a single MO and the baseline No Action Alternative insofar as it relates to trends in hydraulic departure for a select MO. It is also important to note that the stochastic hydrology for the No Action Alternative (see Section 3.2) was derived assuming climactic stationarity (i.e., without climate change). A discussion of sediment and geomorphology for the No Action Alternative under a future with climate change is presented separately in Chapter 4.

Due to the large size of the study area, the spatiotemporal variability of supporting calibration data (e.g., bed material gradation and sediment supply), and limitations of the base input planning models, the scalar magnitude of a select metric at a discrete location and time may not necessarily represent actualized conditions. The quantitative metrics were interpreted within a subreach context to estimate qualitative trends for anticipated impacts at various locations within the study area. In addition, for the Environmental Consequences assessment of the *Breach Snake Embankments* measure under MO3, a numerical mobile bed riverine hydraulic model was developed as described in Section 3.4 of Appendix C. Additional detail regarding the geomorphology and sediment transport metrics can be found in Appendix C.

**STORAGE PROJECT METRICS**

There are six CRS dams that are designed and operated for flood, irrigation, or other storage purposes: Libby, Hungry Horse, Albeni Falls, Grand Coulee, John Day and Dworshak. Note that while John Day can be operated as a run-of-river project, it also includes a small amount of storage and thus was also evaluated for the storage project metrics. Operators change the pool elevation at these storage projects over large ranges throughout the year to capture and release water in specifically managed ways.

**Head of Storage Reservoir Sediment Mobilization**

The head-of-reservoir sediment mobilization metric is designed to indicate the potential for changes in sediment scour and deposition patterns in the most upstream portion of storage reservoirs. In dams that use large amounts of storage volume and operate over a wide range of elevations throughout the year, the transition from riverine to reservoir conditions can shift upstream and downstream considerable distances. If reservoir drawdown leaves the delta exposed during high-flow periods, the upper layers of delta will be eroded and transported farther into the reservoir, potentially increasing turbidity and downstream sediment deposit thickness. Changes in storage project elevations or changes to the flow of water and sediment into the reservoir can result in changes to the head-of-reservoir erosion and deposition patterns. This metric compares the paired relationships of flow and stage over time to indicate the potential for change in sediment mobilization at the head-of-reservoir for each alternative. Changes in delta sediment mobilization could alter the sediment load farther downstream within the reservoir and potentially the amount of sediment passing a dam, particularly during high-flow periods.

**Storage Reservoir – Sediment Trap Efficiency**

The sediment trap efficiency metric estimates the potential for changes in the amount of sediment that can deposit within or pass through the storage reservoirs. Trap efficiency is the proportion of inflowing sediment deposited in the reservoir relative to the total incoming sediment load. The trap efficiency is computed based on the ratio of reservoir storage volume to annual inflow. Because the volume of water stored at any given time in the storage projects can vary between MOs, there is potential for the amount of material being deposited in the reservoir to change between MOs. This metric compares the paired relationship of flow and reservoir storage to indicate the potential for changes in the amount of sediment being trapped by the storage projects for each alternative. The actual amount of sediment trapped is dependent not only on trap efficiency but also the incoming sediment load. Qualitative inferences are discussed on potential trap efficiency changes using sediment source documentation where available in the affected environment section (3.3.2).

**Storage Reservoir – Shoreline Exposure**

Shoreline erosion of bank sediments along reservoir margins is a complex process that is influenced by the cumulative effects of wave erosion, reservoir currents, precipitation runoff, freeze-thaw, soil properties, exposure, and vegetation density and type. One commonly observed process is that during times of extended reservoir drawdown, exposed un-vegetated shoreline soils that were previously saturated are prone to erosion and slumping. The shoreline exposure metric was developed as a surrogate for shoreline erosion processes. It compares the number of days that the reservoir water surface spends at any elevation to identify change in shoreline exposure and indicate the potential for change in shoreline erosion in the CRS storage projects. Elevation-duration curves used in this metric are developed from daily average data extracted from the 5,000-year stochastic hydroregulation operations model. The curves are integrated to calculate an average and are compared with the average of the No Action Alternative baseline. While the shoreline exposure metric does not directly consider reservoir draft rate, it does represent the duration effects that could result from draft rate operational measures.

Absolute shoreline exposure differences less than ±5 feet are likely not discernable within a storage reservoir due to sub-daily operational fluctuations and other processes such as waves, which occur within a similar range. A difference of at least ±5 feet is estimated to be the threshold when shoreline effects would be observable on the landscape and would be considered minor. Differences greater than ±10 feet would be observable and would be expected to result in moderate changes in shoreline exposure. A modification in the operational range of a storage project would be required to generate major changes in shoreline exposure with existing shoreline becoming permanently exposed or submerged. However, none of the analyzed MO operational measures changed the operational range at the CRS storage projects.

An additional metric for shoreline erosion was developed to evaluate potential impacts to cultural resources. This metric considered draft frequency and amplitude and is detailed in Section 3.16.3.

**RUN-OF-RIVER RESERVOIR AND FREE-FLOWING REACH METRICS**

The remaining CRS reservoirs within the study area (Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, and Bonneville) are run-of-river dams that do not store water for later discharge. Note that while John Day includes a small amount of storage, it can also be operated as a run-of-river project. Run-of-river reservoirs and free-flowing reaches include all the river reaches downstream of CRS storage projects. Run-of-river reservoirs are formed by dams that are operated to discharge water downstream at rates that generally match the upstream inflows. Bonneville Dam is an example of a run-of-river project that operates in a small range of pool elevations for daily or weekly hydropower purposes but does not attempt to store water for release in later seasons. Free-flowing reaches are portions of the river that are not influenced by the backwater of a downstream reservoir. The Flathead River downstream of Hungry Horse Dam and upstream of Flathead Lake is an example of a free-flowing reach.

**Potential for Sediment Passing Reservoirs and Reaches**

This metric estimates the size of material that can be held in suspension in the water column through each run-of-river reservoir and free-flowing reach due to operations of CRS projects. Water flowing in nature is predominately turbulent with chaotic changes in flow intensity and direction occurring at many scales internal to the overall downstream movement of the water. These turbulent forces can be strong enough to hold small sediment particles in suspension in the water column. The more energetic the turbulent forces, the larger the particle that can be suspended. Changes in the hydraulic conditions within the run-of-river reservoirs and reaches can change the ability of the river to transport sediment high in the water column. This metric calculates the grain size that can be held with 100 percent of its transporting mass in suspension for a given hydraulic condition using the Rouse profile (Rouse 1937). Comparison of the suspended sediment size between MOs as well as upstream and downstream in a single MO can inform managers whether there is potential for changes in material passing through or settling in a run-of-river reservoir or free-flowing reach.

**Potential for Bed Material Change**

This metric is designed to indicate the hydraulic potential for the bed of the river to become coarser (sand to gravel) or finer (gravel to sand) due to operations of CRS projects. Changes in operations can alter hydraulic conditions in run-of-river reservoirs and free-flowing reaches such that the river can move more or less riverbed sediment of various size classes. A change in the hydraulic ability for a reach to move sediment does not necessarily indicate that bed material will change. Sediment of specific size classes must be available in the reach at a sufficient supply for a change to occur. A bedrock or heavily armored (i.e., coarse) bed may withstand increases in the hydraulic capacity to transport sediment without changing. Conversely, a decrease in hydraulic ability to move sediment may not result in finer material depositing if no finer material is being locally supplied or transported into the reach. This metric calculates the distribution of critical grain size at the subreach level for each alternative supplemented with qualitative interpretation of existing bed material and sediment load to estimate if there is potential for bed material to trend coarser or finer in run-of-river reservoirs and reaches.

**Potential Changes in Width-Depth Ratio**

This metric evaluates if proposed changes in reservoir operations will alter the range and frequency of W/D ratios relative to affected environment conditions. Storage reservoirs and run-of-river reservoirs alter the physical landscape of rivers. Reservoirs change the width and depth of river channels and connectivity to floodplain surfaces and wetlands. Changes in the river framework alter ecological functions, including habitat, water quality, and riparian corridors, to name a few. The affected environment has larger wetted widths and hydraulic depths relative to pre-dam conditions due to reservoir conditions. Changes in the W/D ratio can indicate a potential for departure in channel hydraulics, or wetland and floodplain availability. MOs that do not change the minimum or maximum operating levels within a reservoir affected reach would not be expected to have a change in W/D ranges. However, operation changes could alter the frequency of W/D ratios, affecting the frequency of connectivity to floodplain surfaces or wetlands depending on local topography. A dam breaching would be expected to result in the largest change to W/D ratios.

**Potential Changes to Navigation Channel Dredging Volumes**

This metric evaluates if there is an expected change in the volume of sediment needing to be dredged from the federally authorized navigation system to provide safe and efficient deep- and shallow-draft navigation. As a part of its Congressional authorization, the Corps operates and maintains the navigation system from Lewiston, Idaho, to the Pacific Ocean along the Snake and Columbia Rivers. Changes in flow have the potential to change the volume of material depositing in the navigation channel. This metric estimates the average annual volume of sediment depositing in the deep- and shallow-draft sections based on relationships between flow in the river and sediment shoaling and historical dredging rates.

**ALTERNATIVE COMPARISON THRESHOLDS**

The River Mechanics Technical Appendix (Appendix C) discusses the quantitative basis for the impact metrics and the thresholds for impact assessment. While the impact thresholds are specific to each metric, the five standardized levels can generally be described as listed in Table 3-51.

**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. |

An example of a minor impact in the "Potential for Bed Material Change" metric would be hydraulic conditions modified from No Action Alternative such that the median grain size in the bed (by mass) could change by up to 10 percent of a grain size class. This means that a fine sand bed reach would still have fine sand bed. A moderate impact would mean the bed material could change by up to 50 percent of a grain size class. A major impact would mean the bed material could change by one whole grain class or more. An example of a major impact would be a reach where the bed material could change from a fine sand to a medium sand or coarser (larger grain sizes) or from a fine sand to a very fine sand or finer (smaller grain sizes).

### *3.3.3.2 NO ACTION ALTERNATIVE*

Environmental consequences under the No Action Alternative are defined as the geomorphology and sediment transport conditions that would be expected within the CRS study area, without any changes in system configuration, maintenance, or operation. In other words, the No Action Alternative shows what would happen if proposed new action was not taken (Bass, Henderson, and Bogdan 2001) and project operations, maintenance, and configuration remained the same as they were in September 2016 (the EIS Notice of Intent date). For this No Action Alternative assessment, future geomorphology and sediment transport conditions are evaluated for the next 50 years. River mechanics metrics related to the No Action Alternative are generally described below from a process-based perspective, and then further summarized by region for any unique location-specific impacts (Table 3-52).

Under the No Action Alternative, water storage patterns are expected to be generally within the same range as historically experienced. There is a wide range in the water elevation in the storage reservoirs depending on the season and precipitation, and this variation will continue to control the location of the transition between riverine and reservoir conditions. The flow rates and project operating stages within the system are expected to remain within the historical range of variations. The incoming flow rate and downstream stage within a river segment or reservoir directly affect the hydraulic grade, which is the primary driver of sediment transport and suspension.

Shoreline erosion occurs to varying degrees in the storage reservoirs, depending on water level, wind (wave erosion), ice, currents, and other processes. Under the No Action Alternative, the duration and timing of reservoir water levels are not expected to change compared to the historical range. Similarly, it is anticipated that winds, freeze-thaw patterns, and flow rates within the reservoir would be within the historically experienced range.

Under the No Action Alternative, climatic conditions, land use patterns, and the amount of sediment entering the reservoirs from upstream is expected to remain the same as historically experienced. Climatic conditions, land use, and precipitation are major drivers for sediment erosion and yield into the river system. Climatic conditions were assumed to be consistent within historical ranges. The range of precipitation is expected to be within the historical range experienced, including some very wet and some very dry years. Land use is anticipated to follow similar patterns as currently experienced, with discrete population centers in some areas, but with a large portion of the watershed held as public lands. Sources of sediment such as agricultural fields are expected to continue cultivation in a manner similar to the current conditions. Under the No Action Alternative, the sediment loading throughout the basin is not expected to change from the historical range experienced.

**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. |

### REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

#### Storage Projects

Under the No Action Alternative in Region A, sediment transport, deposition, and erosion processes will continue to be impacted by CRSO. Head of Reservoir Sediment Mobilization, Trap Efficiency, and Shoreline Exposure processes will continue at a similar magnitude and rates to those described in the Affected Environment (Section 3.3.2.3).

#### Run-of-River Reservoir and Free-Flowing Reaches

Under the No Action Alternative in Region A, the Run-of-River Reservoir and Free-Flowing Reaches will continue to be impacted by CRSO. The sediment loads passing through each reservoir, altered bed material gradation, and altered W/D ratios will continue at magnitudes and rates similar to those described in the Affected Environment (Section 3.3.2.4).

### REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

#### Storage Projects

Under the No Action Alternative in Region B, negligible change is expected in Storage Project metrics for Head of Reservoir Sediment Mobilization, Trap Efficiency, and Shoreline Exposure indicating that these processes will continue at magnitudes and rates similar to those described in the Affected Environment (Section 3.3.2.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

#### Run-of-River Reservoir and Free-Flowing Reaches

Under the No Action Alternative in Region B, negligible change is expected in the Run-of-River Reservoir and Free-Flowing Reach metrics for potential changes in Sediment Passing Reservoirs and Reaches, Bed Material Change, and Width-to-Depth Ratio, indicating that these processes will continue at magnitudes and rates similar to those described in the Affected Environment (Section 3.3.2.4). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

### REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

#### Storage Projects

Under the No Action Alternative in Region C, negligible change is expected in Storage Project metrics for Head of Reservoir Sediment Mobilization, Trap Efficiency, and Shoreline Exposure indicating that these processes will continue at magnitudes and rates similar to those described in the Affected Environment (Section 3.3.2.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

#### Run-of-River Reservoir and Free-Flowing Reaches

Under the No Action Alternative in Region C, negligible change is expected in the Run-of-River Reservoir and Free-Flowing Reach metrics for Potential changes in Sediment Passing Reservoirs and Reaches, Bed Material Change, and Width-to-Depth Ratio, indicating that these processes will continue at magnitudes and rates similar to those described in the Affected Environment (Section 3.3.2.4). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

Under the No Action Alternative in Region C, negligible change is expected in the accumulation of sediment and FNC maintenance requirements. The negligible change results from negligible change in various factors that affect sediment accumulation including climatic conditions, watershed yield and loading to the reservoir, the hydraulic capacity to transport sediment material through the reservoir, and changes in the bed materials as detailed above. Currently dredging within the system occurs on the lower Columbia River and on the lower Snake River, in discrete locations. Areas which historically have required dredging (lock chamber approaches, the confluence of the Snake and Clearwater Rivers, harbor and port berthing areas and entrances) would still experience shoaling (buildup of sediment into shallow areas). Dredging within the LCR FNC and private dock-face/berthing areas to maintain navigation would still occur. Sediment management activities in the Snake River (as described in the PSMP, Corps 2014c) would continue as currently planned.

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

#### Storage Projects

Under the No Action Alternative in Region D, negligible change is expected in Storage Project metrics for Head of Reservoir Sediment Mobilization, Trap Efficiency, and Shoreline Exposure, indicating that these processes will continue at magnitudes and rates similar to those described in the Affected Environment (Section 3.3.2.3). The negligible change in these metrics results from negligible change in water storage patterns, seasonal reservoir elevations, sediment loading, and sediment properties.

**Run-of-River Reservoir and Free-Flowing Reaches**

Under the No Action Alternative in Region D, negligible change is expected in the Run-of-River Reservoir and Free-Flowing Reach metrics for Potential Changes in Sediment Passing Reservoirs and Reaches, Bed Material Change, and Width-to-Depth Ratio, indicating that these processes will continue at magnitudes and rates similar to those described in the Affected Environment (Section 3.3.2.4). The negligible change in these metrics results from negligible change in flow rates, operating levels, hydraulic energy regime, sediment sources and loading, and sediment properties.

Under the No Action Alternative in Region D, negligible change is expected in the accumulation of sediment and FNC maintenance requirements. The negligible change results from negligible change in various factors that affect sediment accumulation including climatic conditions, watershed yield and loading to the reservoir, the hydraulic capacity to transport sediment material through the reservoir, and changes in the bed materials as detailed above.

### *3.3.3.3 MULTIPLE OBJECTIVE ALTERNATIVE 1*

See Section 2.3.3 for a complete description of MO1. Impacts related to MO1 relative to the No Action Alternative are summarized by region and enumerated in Table 3-53.

**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:<br>**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 *Winter System FRM Space* 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 *Modified Dworshak Summer Draft* 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:<br>**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 *Winter System FRM Space* 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:**<br>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.<br>**Lower Columbia River:**<br>Estimated average annual volume of sediment depositing in the LCR FNC due to MO1 operations is less than 1% decrease from the NAA. |

## REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

### Storage Projects

Negligible change in Region A Storage Project metrics under MO1.

### Run-of-River Reservoir and Free-Flowing Reaches

Negligible change in Region A Run-of-River Reservoirs and Free-Flowing Reach metrics under MO1.

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

### Storage Projects

Negligible change in Region B Storage Project metrics under MO1 with the exception of Head of Reservoir Sediment Mobilization at the **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 *Winter System FRM Space* measure at Grand Coulee Dam contributes to the impact.

**Run-of-River Reservoir and Free-Flowing Reaches**

Negligible change in Region B Run-of-River Reservoirs and Free-Flowing Reach metrics under MO1 with the exception of the Potential for Bed Material Change at the **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 *Winter System FRM Space* measure at Grand Coulee Dam contributes to the impact.

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

**Storage Projects**

Negligible change in Region C Storage Project metrics under MO1.

**Run-of-River Reservoir and Free-Flowing Reaches**

Negligible change in Region C Run-of-River Reservoirs and Free-Flowing Reach metrics under MO1 with the exception of the potential for sediment to pass run-of-river reservoirs and free-flowing reaches on the **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 *Modified Dworshak Summer Draft* measure causes the impact. Negligible change in Region C to Navigation Channel Dredging volumes was estimated under MO1.

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

**Storage Projects**

Negligible change in Region D Storage Project metrics under MO1.

**Run-of-River Reservoir and Free-Flowing Reaches**

Negligible change in Region D Run-of-River Reservoirs and Free-Flowing Reach metrics under MO1. Negligible change in Region D Navigation Channel Dredging volumes was estimated under MO1.

### *3.3.3.4 MULTIPLE OBJECTIVE ALTERNATIVE 2*

Refer to the complete alternative description in Section 2.3.4. Impacts related to MO2 relative to the No Action Alternative are summarized by region and enumerated in Table 3-54.

**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:<br>**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 *Slightly Deeper Draft for Hydropower* 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:<br>**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 *Slightly Deeper Draft for Hydropower* measure causes the impact.<br><br>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 *Planned Draft Rate at Grand Coulee* 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:<br>**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 *Slightly Deeper Draft for Hydropower* measure during winter months.<br>**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 *Winter System FRM Space* and *Slightly Deeper Drafts for Hydropower* 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 | **Snake River:**<br>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.<br>**Lower Columbia River:**<br>Estimated average annual volume of sediment depositing in the LCR FNC due to MO2 operations is less than 1% increase from the NAA. |

## REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

### Storage Projects

Negligible change in Region A Storage Project metrics under MO2.

### Run-of-River Reservoir and Free-Flowing Reaches

Negligible change in Region A Run-of-River Reservoirs and Free-Flowing Reach metrics under MO2 with the exception of Potential for Bed Material Change within the **Lower Flathead River between Stillwater and Flathead Lake (*Subreach 28.13*).** There is potential for a minor 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 dampen 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 result from the *Slightly Deeper Draft for Hydropower* measure during winter months.

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

### Storage Projects

Negligible change in Region B Storage Project metrics under MO2.

### Run-of-River Reservoir and Free-Flowing Reaches

Negligible change in Region B Run-of-River Reservoirs and Free-Flowing Reach metrics under MO2 with the exception of the Potential for Bed Material Change within the **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 *Winter System FRM Space* and *Slightly Deeper Drafts for Hydropower* measures at Grand Coulee contributes to the impact.

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

**Storage Projects**

Negligible change in Region C Storage Project metrics under MO2 with the exception of Head of Reservoir Sediment Mobilization and Shoreline Exposure at Dworshak Reservoir. There is potential for a minor change in depositional patterns with temporary head-of-reservoir deposits shifting downstream at Dworshak Reservoir. The ultimate long-term fate of head-of-reservoir sediments within the reservoir is unchanged given no changes in Dworshak operational range. The *Slightly Deeper Draft for Hydropower* measure causes the impact. There is also 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 *Slightly Deeper Draft for Hydropower* measure causes the impact.

**Run-of-River Reservoir and Free-Flowing Reaches**

Negligible change in Region C Run-of-River Reservoirs and Free-Flowing Reach metrics under MO2. Negligible change in Region C Navigation Channel Dredging volumes under MO2.

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

**Storage Projects**

Negligible change in Region D Storage Project metrics under MO2.

**Run-of-River Reservoir and Free-Flowing Reaches**

Negligible change in Region D Run-of-River Reservoirs and Free-Flowing Reach metrics under MO2. Negligible change in Region D Navigation Channel Dredging volumes under MO2.

### *3.3.3.5 MULTIPLE OBJECTIVE ALTERNATIVE 3*

See Chapter 2 for a complete description of the dam embankment breach alternative. Structural measures for this alternative include:

- Breach Snake Embankments: Remove earthen embankments, as required, at each dam to facilitate reservoir drawdown at the lower Snake River dams.
- Lower Snake Infrastructure Drawdown: Modify existing equipment and dam infrastructure at the lower Snake River dams to adjust to drawdown conditions (Existing equipment would not be used for hydropower generation but would be used as low-level outlets for drawdown below spillway elevations).
- Additional Powerhouse Surface Passage: Construct additional powerhouse and surface passage routes at the McNary Project.

Under MO3, four reservoirs will be drawn down and converted to a riverine environment. The current reservoirs contain fine sediment deposits that will partially erode, leaving margin sediment on high terraces behind. The new 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. River Mechanic metric impacts related to MO3 relative to the No Action Alternative are summarized by region and enumerated in Table 3-55. See Appendix C, *River Mechanics Technical Appendix*, for additional information on estimated dam breaching impacts.

**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 | Negligible change in the potential for sediment to pass run-of-river reservoirs and free-flowing reaches with the exception of:<br>**The Snake River from the upstream extents to Lower Granite Reservoir downstream to the Columbia River (*Reaches 6–9 and 11.1*)** and the **Clearwater River backwatered by Lower Granite Reservoir (*Subreach 10.1*)**. There is potential for a major increase in the size and amount of sediment passing these reaches. The *Breach Snake Embankments* measure causes the impact by converting four run-of-river reservoirs to a riverine environment.<br>**Columbia River from the Snake River confluence downstream to the Pacific Ocean (*Reaches 1–5*).** 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 *Breach Snake Embankments* measure causes the impact. |

| Metric | MO3 Impact |
|---|---|
| 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:<br>**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 *Breach Snake Embankments* measure causes the impact.<br>**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 *Breach Snake Embankments* causes the impact. |
| Potential Change in Width to Depth Ratio | Negligible change in the overall geomorphic character of the rivers with the exception of:<br>**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 *Breach Snake Embankments* 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. |
| Potential Changes to Navigation Channel Dredging Volumes | **Snake River:**<br>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.<br>**Lower Columbia River:**<br>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. |

## REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

### Storage Projects

Negligible change in Region A Storage Project metrics under MO3.

### Run-of-River Reservoir and Free-Flowing Reaches

Negligible change in Region A Run-of-River Reservoirs and Free-Flowing Reach metrics under MO3.

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

### Storage Projects

Negligible change in Region B Storage Project metrics under MO3.

### Run-of-River Reservoir and Free-Flowing Reaches

Negligible change in Region B Run-of-River Reservoirs and Free-Flowing Reach metrics under MO3. 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 *Planned Draft Rate at Grand Coulee* could have the potential to provide minor reductions in local landslides related to reservoir levels.

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Storage Projects

Negligible change in Region C Storage Project metrics under MO3.

### Run-of-River Reservoir and Free-Flowing Reaches

Within Region C, significant changes were identified under MO3 for the Run-of-River Reservoirs and Free-Flowing Reach metrics caused by the *Breach Snake Embankments* measure, which converts four run-of-river reservoirs to a riverine environment. The spatial impact of change includes **the Snake River from the upstream extents to Lower Granite Reservoir downstream to the Columbia River confluence (*Reaches 6–9 and Subreach 11.1*)** and the **Clearwater River backwatered by Lower Granite Reservoir (*Subreach 10.1*).** Within these reaches, there is potential for a major increase in the size and amount of sediment passing and a major amount of coarsening of bed sediment. There is also a major change in geomorphic character in these reaches, with the river becoming much shallower relative to its wetted width. 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.

Under MO3, navigation maintenance of the Snake River FNC is assumed to cease following breaching of the four Snake River projects. Following breaching of the dam embankments, watershed sediment will now pass the breached dam embankments and be routed to the Columbia River confluence.

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

**Storage Projects**

Negligible change in Region D Storage Project metrics under MO3.

**Run-of-River Reservoir and Free-Flowing Reaches**

Within Region D, changes were identified under MO3 for the Run-of-River Reservoirs and Free-Flowing Reach metrics caused by the *Breach Snake Embankments* measure which converts four run-of-river reservoirs to a riverine environment. Due to the increase in the 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. 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.

Under MO3, negligible changes were estimated in Region D Navigation Channel Dredging volumes based on sediment loads supplied from Region B. 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.

### *3.3.3.6 Multiple Objective Alternative 4*

A complete description of MO4 can be found in Section 2.3.6. The MO includes structural measures as well as operational measures. The structural measures are related to powerhouse, turbine, spillway and fish passage features, and do not include the breaching of any dams. The operational measures include a long list of changes to current flow and power operations, including increasing the irrigation to authorized amounts which are detailed in Chapter 2. Impacts related to MO4 relative to the No Action Alternative are summarized by region and enumerated in Table 3-56.

**Table 3-56. Summary of Multiple Objective Alternative 4 River Mechanics Impact Estimates**

| Metric | MO4 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:<br>**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 *Winter System FRM Space*, *Planned Draft Rate*, and *McNary Flow Target* measures at Grand Coulee contribute to the impact.<br>**Columbia River Entering John Day Reservoir.** There is potential for a minor change in head-of-reservoir sediment mobilization with deposits becoming coarser. The *Drawdown to MOP* measure at the John Day Project 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 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 *Hungry Horse Additional Water Supply* and *McNary Flow Target* measures causes the impact.<br>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 *Planned Draft Rate at Grand Coulee* 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 with the exception of<br>**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 *Winter System FRM Space*, *Planned Draft Rate*, and *McNary Flow Target* measures at Grand Coulee are contributors the impact. |

| Metric | MO4 Impact |
|---|---|
| Potential for Bed Material Change | Negligible change in the processes that supply, transport and deposit sediment in the system with the exception of:<br>**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. *Winter System FRM Space*, *Planned Draft Rate* and *McNary Flow Target* measures at Grand Coulee contribute to the impact.<br>**Snake River downstream of Ice Harbor (*Subreach 6.1*).** There is potential for a minor amount of bed sediment coarsening. The *Drawdown to MOP* measure at the McNary Project is causing in the impact.<br>**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 *Drawdown to MOP* measure at the McNary Project is causing in the impact.<br>**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 *Drawdown to MOP* measure at the John Day Project causes the impact.<br>**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 *Drawdown to MOP* measure at The Dalles and Bonneville Projects causes this 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:**<br>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.<br>**Lower Columbia River:**<br>Estimated average annual volume of sediment depositing in the LCR FNC due to MO4 operations is a less than 1% decrease from No Action. |

## REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

### Storage Projects

Negligible change in Region A Storage Project metrics under MO4 with the exception of Shoreline Exposure at 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 *Hungry Horse Additional Water Supply* and *McNary Flow Target* measures causes the impact.

### Run-of-River Reservoir and Free-Flowing Reaches

Negligible change in Region A Run-of-River Reservoirs and Free-Flowing Reach metrics under MO4.

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

### Storage Projects

Negligible change in Region B Storage Project metrics under MO4 with the exception of Head of Reservoir Sediment Mobilization on the **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. 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. The *Winter System FRM Space*, *Planned Draft Rate*, and *McNary Flow Target* measures at Grand Coulee contribute to the impact. 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 *Planned Draft Rate at Grand Coulee* could have the potential to provide minor reductions in local landslides related to reservoir levels.

### Run-of-River Reservoir and Free-Flowing Reaches

Negligible change in Region B Run-of-River Reservoirs and Free-Flowing Reach metrics under MO4 with the exception of the Potential for Sediment Passing Reservoirs and Reaches and Potential for Bed Material Change with *Winter System FRM Space*, *Planned Draft Rate,* and *McNary Flow Target* measures at Grand Coulee contributing to the impacts. On 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. On the **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.

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Storage Projects

Negligible change in Region C Storage Project metrics under MO4.

### Run-of-River Reservoir and Free-Flowing Reaches

Negligible change in Region C Run-of-River Reservoirs and Free-Flowing Reach metrics under MO4 with the exception of the potential for a minor amount of bed sediment coarsening on the **Snake River downstream of Ice Harbor (*Subreach 6.1*)**. The *Drawdown to MOP* measure at the McNary Project is causing in the impact. Negligible change in Region C Navigation Channel Dredging volumes under MO4.

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

**Storage Projects**

Negligible change in Region D Storage Project metrics under MO4 with the exception of Head of Reservoir Sediment Mobilization on the **Columbia River Entering John Day Reservoir.** There is potential for a minor change in head-of-reservoir sediment mobilization with deposits becoming coarser. The *Drawdown to MOP* measure at the John Day Project causes the impact.

**Run-of-River Reservoir and Free-Flowing Reaches**

Negligible change in Region D Run-of-River Reservoirs and Free-Flowing Reach metrics under MO4 with the exception of the Potential for Bed Material Change. On the **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 *Drawdown to MOP* measure at the McNary Project is causing in the impact. On the **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 *Drawdown to MOP* measure at the John Day Project causes the impact. On the **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 *Drawdown to MOP* measure at The Dalles and Bonneville Projects causes this impact. Negligible change in Region D Navigation Channel Dredging volumes under MO4.

### 3.3.4 Tribal Interests

As described above, MO1, MO2, and MO4 generally result in negligible to minor changes in metrics used to analyzed effects to river mechanics processes. Tribal interests under those alternatives would not be impacted. MO3 includes a measure to breach the downstream-most four dam embankments on the Snake River which would result in major changes to river mechanics processes and corresponding metrics. The MO3 alternative would change the lower Snake River landscape that is currently backwatered by the four dams (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) and the localized areas of the Columbia River below the Snake River confluence.

Areas that are currently inundated by the Snake River reservoirs will become free-flowing river sections, although the incoming hydrology may still be regulated by upstream dams where present. Along the reservoir margins, some higher elevation surfaces will be abandoned and no longer inundated after the breaching of the dams. These newly exposed surfaces could contain cultural resources important to tribes that will no longer be protected by inundation from the reservoirs. Sediment currently stored in the reservoirs will either become part of the new river and floodplain features, transported downstream, or be left behind on the abandoned margin surfaces. During dam embankment breaching and in the near term (up to 10 years) following, sediment loads downstream will be elevated as the Snake River erodes and processes the sediment deposits behind the dams and residual deposits left on higher terrace surfaces. These higher sediment loads may affect current tribal access and types of recreation and fisheries use in the former reservoirs and downstream areas altered from changed sediment conditions.

Over the long term, watershed sediment loads that were historically trapped behind the lower Snake River Dams will be seasonally routed to the Columbia River where it is expected to deposit primarily in the upper 10 miles of the McNary Reservoir between the confluence and Wallula, Washington. Over the long term, the free-flowing river conditions will provide alternate recreation and fisheries opportunities discussed in other EIS chapters.

## 3.4 WATER QUALITY

The water quality of the Columbia River Basin is affected by many past and present influences, including human population growth and associated pollutants, water withdrawal for municipal and industrial water and irrigation (and irrigation return flows), dam structures and operations (Federal and non-Federal), and land use practices including mining, domesticated livestock, agriculture, industry (pulp and paper mills), logging (silviculture and forest management), and recreation (e.g., shoreline erosion). New pollutants are continually being identified, such as pharmaceuticals (Nielsen et al. 2014); the existing National Pollutant Discharge Elimination System programs regulate certain identified compounds from point sources, but other pollutants may also be present and unaccounted for. Nonetheless, surface water in the Columbia River Basin supports a wide variety of resident and anadromous fish and other aquatic organisms and wildlife.

The 14 Federal dams within the CRSO study area have affected water and sediment quality due to the creation of reservoirs throughout the system. Prior to the construction of these and other dams, the Columbia River and its tributaries were free-flowing, natural rivers. These rivers experienced seasonal flow and temperature changes. The seasonal peak flows would have moved sediment downstream over time. Water depths would have been comparatively shallow (more shallow than the current reservoirs) which has implications for water velocity, water temperature, and ecological processes. Water in the river was fully mixed as the water flowed downstream. The river conditions dictated the water and sediment quality, which in turn dictated the habitat and species found in the habitat.

The Corps and Reclamation constructed the 14 Federal dams in the Columbia River System and manage the water flowing through the dams for the various authorized purposes. The dam structures and operations reduce river velocity, dampening the hydrograph relative to the undammed river condition. The dams interrupt the connectivity of the river, creating a series of reservoirs that act more like lentic (lake) rather than lotic (riverine) systems, ultimately changing water quality processes.

In general, large dams have an influence on the riverine ecosystem downstream of the structure (Ward and Stanford 1983; Nillson and Berggren 2000). Dams alter flow regime, temperature, oxygen dynamics, sediment dynamics, and channel geomorphology (shape and function) (Shields et al. 2000; Stanford and Ward 2001). Depending on the mode and pattern of operation, dams function to reduce frequent peak flows and raise baseflow stage and discharge in the stream below. Reduction in peak flows acts to decouple a frequent flood or overbank event from the historical floodplain or riparian zone, which converts a floodplain river to a reservoir river (flood pulse concept, Junk et al. 1989). When a frequent flood event is decoupled from the adjacent floodplain, important natural water quality processes and functions are compromised, including nutrient cycling and transport, contaminant sequestration and sometimes transformation, carbon export and food chain support, and feeding and breeding opportunities for aquatic organisms. Because current dam operations are dependent on runoff conditions, in general, more water is stored and released during high-flow years compared to low-flow years, resulting in variation in water quality conditions from season to season and year to year. During periods of high spill resulting in higher downstream velocities, fine sediment can be resuspended (as wash load) and larger-sized gravel and cobbles are mobilized, which redistributes bedforms and associated aquatic habitat, may cause accelerated sedimentation, and sometimes removes established vegetation within the stream channel. In places, shoreline retreat caused by mass wasting triggered by fluctuating reservoir levels may also occur.

Some reservoirs within the Columbia River Basin stratify. Stratification refers to the different vertical layers which develop in the water column due predominantly to solar warming of the surface (top layers) of the water and subsequent changes in the water's density. Generally, because of this vertical temperature and density gradient, three layers form: epilimnion (top), metalimnion or thermocline (middle), and hypolimnion (bottom) (https://www.nwd.usace.army.mil/CRSO/Documents/). As a result of thermal stratification, water column stability typically increases and mixing between layers is reduced, isolating various physical and biotic processes and leading to differences in concentrations of nutrients and other chemicals between the layers.

Hungry Horse, Libby, and Dworshak dams have deep storage reservoirs that retain water for several months, allowing for stratification. This stratification provides the ability to operate these dams, through selective withdrawal, to support downstream water temperature objectives. Grand Coulee is also considered a storage project, but it is unique in the fact that it has relatively low retention times due to the large amount of flow through the reservoir. This short retention time results in very weak thermal stratification. The other CRS dams (Albeni Falls, Grand Coulee, Chief Joseph, McNary, John Day, The Dalles, Bonneville, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor) have relatively short retention times (only a few days or weeks) and more uniform water temperatures from the surface to the bottom; selective withdrawal is not useful at these dams since they lack strong stratification.

### 3.4.1 Area of Analysis

The area considered in this water and sediment quality evaluation consists of the Columbia River and tributaries (Snake, Clearwater, Pend Oreille, Flathead, and Kootenai Rivers) from the U.S.-Canada border to downstream of Bonneville Dam. This includes the Federal dams of Hungry Horse, Libby, Albeni Falls, Grand Coulee, Chief Joseph, Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville (Figure 3-106).

The water quality analysis for this EIS focused on the area of largest impact both upstream (in the reservoir) and downstream (in the tailrace) of each CRS dam. Operations of the CRS dams have negligible impacts on water and sediment quality in the tidally influenced portion of the Columbia River downstream of Bonneville Dam. These estimates are supported by results that are described in Sections 3.4.3.3 through 3.4.3.6. The descriptions of water quality and potential effects in Lake Koocanusa apply to the reservoir in Canada as well as the United States. Elsewhere in the Canadian portion of the basin downstream of CRS projects, effects to water quality from the CRSO alternatives would not be expected.

In general, it is known that the dams within the Columbia River basin disrupt the movement of sediment, blocking most material from moving downstream of Bonneville Dam, except for small amounts of fine suspended material that are carried to the ocean. It is also recognized that the presence of the dams may impact the lower Columbia River and estuary, simply because the natural processes in the river system have been disrupted by the dams; but the effects of dam construction are not analyzed in this EIS. Other downstream conditions, such as the water and sediment quality in the Portland, Oregon, area, are affected by factors outside the scope of this study, and those downstream conditions may also impact these resources. Existing dredging operations are not considered in this evaluation and are instead covered under other Corps NEPA documents (Corps 1998, 2002).

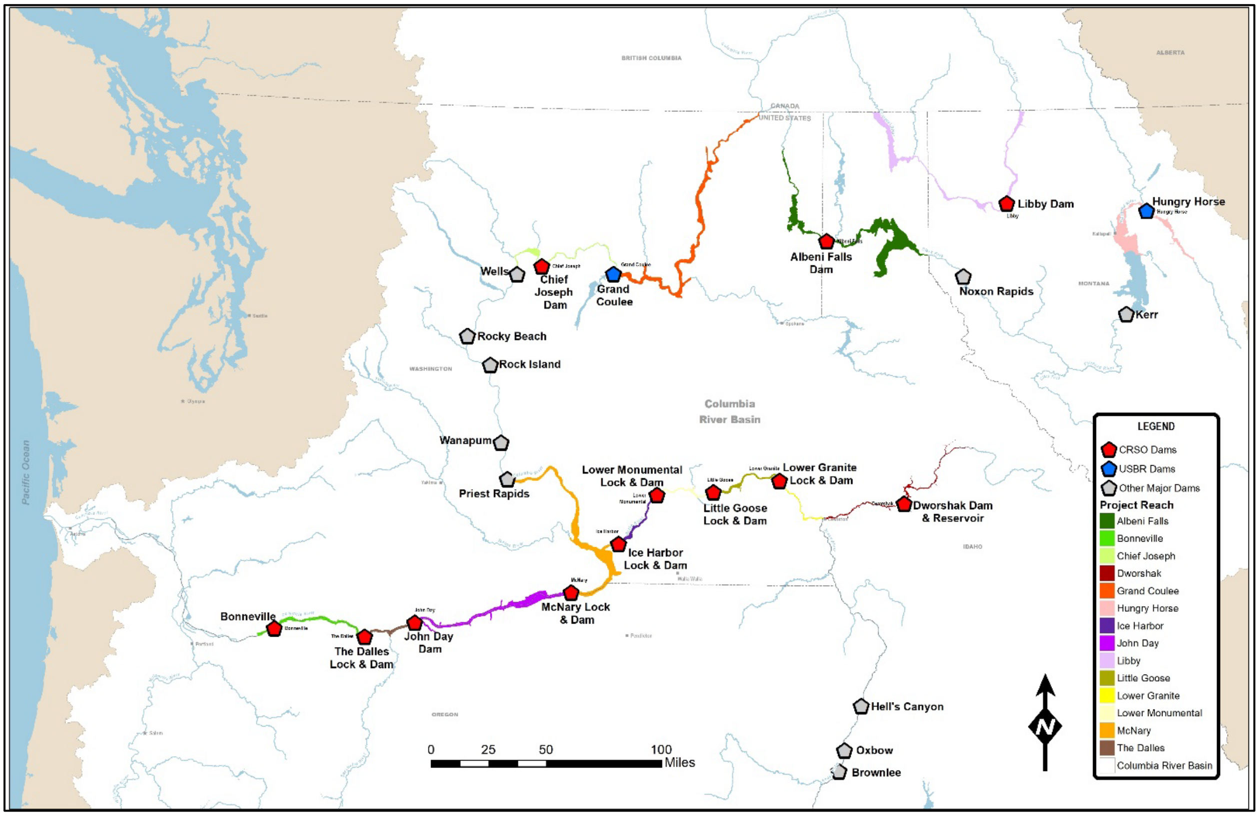



**Figure 3-106. Water Quality Study Area Map**

Note: Colored areas represent the study reaches included in this study.

### 3.4.2 Affected Environment

For this EIS analysis, water quality parameters have been separated into three major categories: (1) water temperature; (2) total dissolved gas (TDG); and (3) other physical, chemical, and biological conditions. This information is summarized in the paragraphs below for each MO.

#### *3.4.2.1 Water Quality*

The Clean Water Act (CWA) is the primary law governing surface water quality in the United States with the goal of restoring and maintaining the chemical, physical and biological integrity of waters (lakes, rivers, streams, wetlands, estuaries and coastal zones) throughout the nation (33 U.S.C. § 1251 et seq.). Under Section 303(d) of the CWA, the states, territories and authorized tribes are required to identify and list impaired waters that do not meet these goals (33 U.S.C. § 1313). The 303(d) list is a report or summary of the impaired waters that are categorized as a Level 5, meaning that water quality standards have not been met for one or more pollutants, and there is no total maximum daily load (TMDL) or pollution control program in place. Multiple waterbodies within the CRSO study area are 303(d) listed. EPA is currently in the process of developing a temperature TMDL.  This is discussed further in Appendix D.

Water quality standards (WQSs) are the legal basis for controlling pollutants entering the waters of the United States. The WQSs describe the desired condition of a water body and the purpose of the condition. The states within the CRSO study area have established their own WQSs and monitoring programs in response to the CWA. Several tribes also have U.S. Environmental Protection Agency (EPA)-approved water quality standards and monitoring programs that apply to portions of the river, including the Confederated Tribes of the Colville Reservation, the Kalispel Tribe of Indians, and Spokane Tribe of Indians. These standards vary by water body and location and protection for various designated uses. Current (2016) state and tribal TDG and water temperature standards are used as the metrics to which all MO analysis results are compared.

TDG saturations[1] in rivers can fluctuate due to a variety of natural and human-caused influences.  Natural influences include total flow, wind, air temperature, barometric pressure, and incoming TDG from upstream and tributaries.  TDG saturation can also increase when dams release water through spillways and other non-turbine outlets. Spilling water at a dam results in increased TDG levels in downstream waters by plunging the aerated spill water to depths where hydrostatic pressure increases the solubility of atmospheric gases. Elevated TDG saturations generated by spill releases from dams are of concern because high saturations can promote the potential for gas bubble trauma in downstream aquatic biota (Weitkamp and Katz 1980; Weitkamp et al. 2002).

Spill operations may be necessary at individual CRS projects in circumstances when river flows exceed powerhouse hydraulic capacity, turbine outages occur, when powerhouse capacity is available but there is no demand for the additional electricity, or when North American Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) requirements apply. These events may limit the co-lead agencies' ability to pass water through the powerhouse and, in some cases, may result in additional spill, which can impact TDG levels. The state and tribal water quality standards for TDG are 110 percent throughout the Columbia River Basin.  To date, the states of Oregon and Washington have provided either standard modifications or criteria adjustments on a short-term basis for the benefit of juvenile fish that are passing the lower four Snake River and lower four Columbia River projects during the juvenile fish passage spill season, which runs from April through August. During this season, the 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.

these modified TDG standards. The state and tribal water quality standards for TDG are 110 percent throughout the Columbia River Basin with the exception of the lower four Snake River and lower four Columbia River projects during the juvenile fish passage spill season, which runs from April through August. During the juvenile fish passage spill season, the lower eight dams are operated in accordance with applicable biological opinions to meet modified TDG standards.[2]

Water temperature is one of the most important physiochemical constituents of surface water and has been modeled as part of the CRS EIS analysis. It controls the rate of all chemical reactions, directly affects fish and benthic macroinvertebrate growth and reproduction, and can be acutely toxic (fatal) to fish if drastic temperature changes occur or if temperatures exceed 25°C for salmon and steelhead.

Water temperatures in many reaches do not meet the regulatory standards in the summer and early fall. System operations can impact both water temperature and TDG in the Columbia River Basin, and given this the impact, the analysis in the CRSO EIS focuses on how both parameters may change with a change in operation as described in the MOs as compared to the No Action Alternative.

**WATER TEMPERATURE**

Hungry Horse Dam is outfitted with a selective withdrawal system (SWS) that allows water to be drawn from various elevations in the reservoir to meet downstream water temperature objectives. The SWS can operate over a pool elevation range from full (3,560 feet) down 160 feet (3,400 feet). However, major modification to the structure(s) is required to enable function over the lower 60 feet of this range, including removal of the upper and intermediate stationary gates.

The SWS at Hungry Horse Dam is operated from approximately June through October to release warmer water, to mimic temperatures similar to those in the Middle and North Fork Flathead Rivers. During winter and spring months, the reservoir's water column is well mixed, with temperatures throughout the water column being nearly equal from top to bottom (isothermal), making selective withdrawal operations ineffective.

Lake Koocanusa is the 90-mile-long reservoir formed by Libby Dam. The thermal conditions in Lake Koocanusa at Libby Dam typically lag seasonal weather conditions by several months due to the long residence time and thermal inertia (massive volume of water that slows warming and cooling within the reservoir). The heat contained in the reservoir during the summer is carried over into the fall and winter months. In general, thermal conditions at Libby Dam typically reach minimum temperatures during late March or early April and are characterized by 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.

temperatures can be in the low 30s°F (0°C to 2°C) range, with surface icing occurring on the shallower upper half of the reservoir. Historical data suggests that the onset of thermal stratification typically begins in late April and May, and is weak and often short lived as weather systems disrupt the thermal structure. Full reservoir mixing and isothermal conditions (i.e., thermal destratification from the loss of heat, at the surface of the lake, back to the atmosphere) generally begins in December.

Libby Dam was designed with a selective withdrawal system (SWS) to manage release water temperatures downstream in the Kootenai River when thermal stratification develops in the reservoir. The selective withdrawal system is operated to provide as close to natural water temperatures as possible downstream in the Kootenai River throughout the year. However, given the presence of a large deep reservoir with stored latent heat as the source of water to the river, outflow temperatures can be cooler in the spring and warmer in the late fall compared to the natural pre-dam Kootenai River. Given this, the selective withdrawal system is operated to follow as best as possible a temperature rule curve developed from pre-dam daily temperatures collected in the Kootenai River from 1967 to 1972 by the Corps and Montana Fish, Wildlife & Parks.

Albeni Falls Dam is located in northern Idaho on the Pend Oreille River about 28 miles downstream of Lake Pend Oreille. Although Lake Pend Oreille is a natural lake, Albeni Falls Dam regulates the upper 11.5 feet of the lake. Albeni Falls Dam has little ability to manage water temperatures in the Pend Oreille River, and water temperature changes in Lake Pend Oreille and the Pend Oreille River are mainly influenced by atmospheric conditions and weather patterns. Lake Pend Oreille is the fifth deepest lake in the United States and exhibits strong thermal stratification regardless of the runoff year. However, a shallow low-water outlet channel acts as a barrier to the transport of much colder deep water from Lake Pend Oreille into the Pend Oreille River resulting in warmer lake surface waters entering the river. The Pend Oreille River TMDL (2011 revised) addresses elevated water temperatures in the summer. Winter water temperatures can be in the low 30s°F (0°C to 2°C) range, with some surface icing during colder winters.

At Grand Coulee Dam, there is little opportunity to manage downstream water temperatures as Lake Roosevelt is weakly stratified. This results in Grand Coulee releasing the coolest water possible in the summer months, based on constraints for generation reliability, voltage stability, and TDG standards. Because of the weak stratification, discharged water temperatures lag the warming/cooling trends observed in the inflow, at the U.S.-Canada border, and tend to be cooler in the spring and warmer in the fall than inflowing conditions. Portions of Lake Roosevelt is currently listed as a Category 5 reach on the state of Washington's 303(d) list for temperature.

Chief Joseph Dam is a run-of-river project located downstream of Grand Coulee Dam. Rufus Woods Lake, the 50-mile-long reservoir formed by Chief Joseph Dam, has an average water retention time (the amount of time water remains in the reservoir) ranging from about 1 to 8 days. Little to no thermal stratification occurs in Rufus Woods Lake, and water temperatures released from Grand Coulee Dam are passed downstream with little change due to the high flows and short retention time in the reservoir. In general, historical hourly temperatures are greater than 60.8°F (16°C) from about the middle of July through late October, and greater than 63.5°F (17.5°C) from about the beginning of August through the end of September. Rufus Woods Lake falls under the state of Washington's 303(d) list Category 5 for temperature due to high water temperatures in the late summer.

Dworshak is a deep, cold-water reservoir that exhibits strong thermal stratification regardless of the runoff year. Summer releases from the project are used to reduce water temperatures downstream in the lower Snake River (Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams) where temperatures historically exceeded the current state of Washington standard of 68°F (20°C), even before the dams were constructed (Corps 2002). Historical temperatures in the lower Snake River Basin prior to the construction of the lower Snake River dams and the Hells Canyon Complex show that temperatures in the free-flowing lower Snake River often exceeded 68°F (20°C) in July and August and occasionally exceeded 25°C. These measurements were taken near the mouth of the Snake River from 1955 to 1958 (Peery and Bjornn 2002). The most noticeable effect can be seen at Lower Granite Reservoir where the tailwater water temperatures are managed to meet, or be less than, the state water quality standard during the summer. The cooling effect in the lower Snake River diminishes at each successive downstream reservoir and the frequency of exceedances above the standard increases. Winter water temperatures are typically in the low 30s°F (0 to 2°C) range, with some surface icing during colder winters.

The four lower Columbia River reservoirs (McNary, John Day, The Dalles, and Bonneville) are on the state of Washington's and Oregon's 303(d) due to elevated water temperatures above the standard of 68°F (20°C). All four reservoirs show weak to no surface warming during the summer months, largely due to the short residence time, wind, and flow-induced turbulent diffusion and convective mixing that occur in the reservoirs. The management of water temperatures in a manner similar to the strategies used on the lower Snake River is not effective in the lower Columbia River because there is not an upstream source of very cold water. Therefore, access to off-channel thermal refugia is critical for the migration and spawning success of anadromous fish (EPA 2020).

**TOTAL DISSOLVED GAS**

Libby and Hungry Horse Dams are both considered high head (tall) dams that tend to generate elevated TDG even when small discharges are released through the dams' non-turbine outlets. Spill at Libby is infrequent, so TDG exceedances are not as commonly seen as in other parts of the CRSO study area. Spill occurs more frequently at Hungry Horse as compared to Libby.

TDG on the South Fork Flathead River downstream of Hungry Horse Dam, to the confluence with the mainstem Flathead River, is of concern for resident fish species. When outflows exceed powerplant capacity, flows must be spilled through the outlet works (hollow-jet valves) or the spillway, which results in supersaturated gases in the downstream river. Based on the level of saturation and the length of exposure, effects can be acute or chronic and may result in mortality of fish in the system (Monk 1997). In high-flow years, TDG often does not meet the state standard of 110 percent below the dam during the spring and early summer due to the release of large amounts of water through outlets known to produce TDG.

In any given year, additional outages can occur due to regulatory requirements, planned maintenance, or unexpected events/equipment failures, which may limit the ability to pass water through the powerhouse and, in some cases, may result in additional spill. Specifically, Reclamation is planning a Hungry Horse Powerplant Modernization and Overhaul Project in the next 10 years (Reclamation 2018). Maintenance would require outages for one year in the powerplant, limiting the powerplant to two units and reducing the hydraulic capacity to approximately 6 kcfs. This could result in additional spill in this 1 year.

Spillway flows from Libby Dam can impact TDG saturations downstream in the Kootenai River. Spillway releases can result in an abrupt increase in TDG to saturations greater than 120 percent. However, in contrast to Hungry Horse Dam, the Libby Dam spillway is operated less frequently. Given this, downstream TDG saturations are less than 110 percent the majority of the time.

Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills most years. In general, spillway operations between 1 to 50 kcfs at Albeni Falls Dam increase downstream TDG saturations by about 0 to 9 percent of forebay saturation depending on the amount of water spilled, the number of spillway bays operating, forebay TDG saturations, and total head. When spill is greater than about 50 to 60 kcfs powerhouse operations are suspended and the spill gates are opened, allowing the river to flow relatively unimpeded across the dam. Under these free-flow conditions there is little to no increase in downstream TDG saturations.

Spill at Grand Coulee Dam occurs when total flows exceed powerhouse capacity during high flows typically observed in the spring and early summer. Spill can also occur during lack of market conditions when there is no demand for additional electricity and hydropower production is unnecessary. Often in high-flow years water flowing into Lake Roosevelt across the U.S.-Canada border is in excess of 110 percent TDG. When Grand Coulee is required to spill to achieve flow or flood risk management (FRM) elevation requirements spill can exceed 130 percent TDG in some cases. The outlet tubes, and to a lesser extent, the drum gates, at Grand Coulee Dam are known to produce elevated TDG when in operation. When reservoir elevations are greater than 1,266 feet, the 11 drum gates can be used to discharge water downstream. The drum gates generate much less TDG than the outlet tubes and are the preferred outlet when available. The 40 regulating outlets are used to discharge water downstream when the forebay elevation is below 1,266 feet, at which point the drum gates become inoperable.

Spill at Chief Joseph Dam is also highly dependent on runoff volume and hydropower operations. Spill can also occur during lack of market conditions when there is no demand for additional electricity. The spillway is equipped with spillway deflectors to reduce TDG loadings to the Columbia River. Spilling at Chief Joseph Dam, when incoming TDG levels are elevated (greater than 120 percent), can reduce system TDG loading, therefore Chief Joseph Dam can be used to manage TDG saturations in the Columbia River. In general, spill at Chief Joseph Dam results in tailwater TDG saturations ranging from about 110 to 120 percent.

Dworshak Dam operations typically produce TDG that is less than 110 percent the majority of the time. Short-term exceptions, however, do occur when additional water is released for FRM purposes.

The four lower Snake River dams are run-of-river projects and TDG production is highly related to runoff volume and water temperature as documented in the TMDL for Lower Snake River Total Dissolved Gas (Washington State Department of Ecology [Ecology] 2003). The state of Washington has issued a short-term criteria adjustment to its TDG water quality standard to not exceed a 12-hour average TDG of 115 percent in the forebay and 120 percent in the tailwater for the purpose of juvenile fish passage during the juvenile fish spill season (generally April through August[3]). Excursions above these thresholds can occur, but are relatively infrequent due to the spillway deflectors and project operations (e.g., spill pattern and amount of spill) that are monitored and adjusted daily. Additionally, TDG saturation can be elevated not only during high-flow periods such as spring runoff, but also during low-flow conditions when the air temperatures are high.

The four lower Columbia River dams are operated for downstream fish passage during the fish passage spill season (April to August). These spill operations are managed to keep TDG saturation levels at or below modified/adjusted state water quality standards for the states of Washington (see above) and Oregon of 120 percent in the downstream tailwater. For the most part, TDG exceedances above these thresholds are minimal during the juvenile fish passage season, which can be attributed to structural enhancements (e.g., spillway deflectors) and operational strategies (e.g., tailoring spill to the configuration of each dam and its associated bathymetry, limiting spill, implementing spill patterns) that have been implemented over the years. Nonetheless, exceedances of the standards do occur under some river and meteorological conditions and there is a TDG TMDL that covers all four lower Columbia River reservoirs (Ecology 2002).

**OTHER PHYSICAL, CHEMICAL, AND BIOLOGICAL PROCESSES**

Hungry Horse Reservoir is considered oligotrophic, meaning it has low concentrations of nutrients required for primary productivity, but is well oxygenated throughout the water column. Due to low food availability (productivity) in the reservoir, resident fish rely on terrestrial insects near the lake’s shore to supplement their diet. Pollutants tend to be relatively low in the Hungry Horse Reservoir and no known pollution problems exist in the reservoir.

Lake Koocanusa would be classified as an oligotrophic to lower mesotrophic (intermediate concentrations of nutrients) water body based on summer concentrations of total phosphorus, chlorophyll a, and transparency (turbidity). The reservoir experiences weak thermal stratification and is well oxygenated throughout the entire water column. Total phosphorus

[3] *Supra* note 8.

concentrations are low and follow a seasonal pattern of increasing during spring runoff and decreasing during the summer and fall. Total phosphorus concentrations are typically two to five times greater at the U.S.-Canada border compared to the forebay, suggesting that Lake Koocanusa acts as a phosphorus sink. Concentrations of nitrate have been increasing throughout Lake Koocanusa since the early 2000s. The major change in the Lake Koocanusa watershed since 2000 is an increase in coal mining operations in the Elk and Fording Rivers watershed in British Columbia, and a corresponding increase in nitrate loading from the waste spoils runoff. Estimates are that the total amount of waste spoils from coal mining operations in British Columbia increased tenfold from 1997 to 2016. In addition, USGS has estimated that increased coal mining in the Elk and Fording Rivers has increased selenium loading to Lake Koocanusa fivefold over the past 20 years (USGS 2014). In general, total selenium concentrations are greatest in the hypolimnion. There does not appear to be a substantial seasonal trend in the data, but concentrations are generally higher in the spring and fall and lower in the summer.

For both Lake Pend Oreille and the Pend Oreille River, in general, summer total phosphorus and nitrate concentrations are low, water clarity is high, and algal growth is moderate. The lake and river are well oxygenated throughout the water column. A nearshore TMDL for nutrients was developed for Lake Pend Oreille in 2002 in response to an increasing trend in nuisance algal growth in the nearshore areas (IDEQ 2015).

Lake Roosevelt is classified as oligotrophic based on chlorophyll a, total nitrogen, total phosphorus, and Secchi depth measurements; however, some variation of this classification does exist both spatially and temporally. One example includes the area of reservoir at the mouth of the Spokane River, which is considered mesotrophic due to the influence of the nutrient-rich Spokane River. The increase in primary productivity due to this nutrient load tends to be localized and does not cause widespread issues for fish.

Historically, pollution from mining and smelting, as well as the atmospheric deposition of mercury, has impacted water quality in Lake Roosevelt. Metals have contaminated bed sediments, and mercury cycling—the process that converts insoluble mercury in the sediment and water into a soluble form (methylmercury)—has become more of a concern. The presence of these pollutants has contributed to fish consumption advisories due to bioaccumulation. These pollutants have likely migrated downstream through Lake Roosevelt. Trace elements have been found in Rufus Woods Lake sediments, suggesting that high flow events may push 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 has occurred in the system. EPA issued a TMDL for dioxin from RM 0 to RM 745 (below Grand Coulee Dam) in 1991, as well as for portions of the Snake River.

Rufus Woods Lake is a well-oxygenated near neutral to slightly basic pH waterbody with low to moderate nutrient concentrations. Small increases in total phosphorus and ammonia concentrations measured downstream of aquaculture facilities in Rufus Woods Lake suggest that these facilities may be a source of these nutrients. Rufus Woods Lake experiences annual harmful algae blooms (HABs) consisting of free-floating surface mats or clumps of algae containing the cyanobacteria *Oscillatoria* and the cyanotoxin anatoxin-a, which is a neurotoxin that can cause severe illness or death in animals and humans if ingested. These mats of algae are found throughout Rufus Woods Lake upstream and downstream of the aquaculture facilities. The increase in HABs is not attributed to the aquaculture facilities. These blooms are a fairly recent water quality issue, and remain unexplained, although HABs are typically caused by excess nutrient loads and enhanced by increased stream and air temperatures. Blooms also occasionally form in other areas of the Columbia, particularly in backwaters. There was a documented exposure (rash) for workers in contact with HABs on the Columbia in Grant County in 2009, for example (Ecology 2009).

Dworshak is a long, relatively narrow reservoir with historically low nutrient concentrations. A lake fertilization project began in 2007 with the goal of increasing productivity by changing the nitrogen to phosphorus ratios in the reservoir, thereby promoting the growth of phytoplankton species that are edible by zooplankton, resulting in improved forage base for fish. Some changes, both increases and decreases, have been documented for several of the chemical and biological parameters that are being monitored under the current lake fertilization project (https://www.nwd.usace.army.mil/CRSO/Documents/). Many of these changes have occurred in areas that are fertilized, as well as reaches that are not fertilized. As the program continues, additional data should help identify whether the observed shifts are due to the fertilization program, changes related to the inflows, natural aging of the lake, or other unidentified causes.

The water quality characteristics of the lower Snake River are, to a large extent, influenced by the inflowing Snake River above the confluence with the Clearwater River. The concentrations of soluble ions and nutrients are lowest during high runoff events when suspended solids are highest. There are usually no significant differences in the concentrations of these constituents, as well as chlorophyll a and algal biovolume, from one reservoir to the next. This is likely due to the relatively short hydrologic residence time of each impoundment.

Within the lower Columbia River, information on other water quality issues is limited. High pH and/or dissolved oxygen in limited portions of the reach from The Dalles to Bonneville Dams resulted in the inclusion of these parameters in the Washington or Oregon 303(d) lists for those stretches. Additionally, some portion of all four reservoirs contain other water quality impairments (mercury and polychlorinated biphenyls [PCBs] have fish consumption advisories and are on 303(d) lists; dioxin has a TMDL). The lower Columbia River contains a wide variety of human-sourced compounds, including metals and organic compounds. Continued pollutant and nutrient loading is expected due to farming activities, industry, and urban and agricultural runoff.

#### ***3.4.2.2 Sediment Quality***

Sediment in the Columbia River Basin is variable in size and composition. Within rivers, sediment originates in the upland areas and riverbanks, as erosion and materials washed or discharged into the river. Coarse-grained material (rock, stone, coarse sand) settles and moves only with the highest flows. Finer-grained material (clay, silt) tends to wash further down the river. In all cases, when the water slows or stops, such as in large reservoirs behind dams, the solids washed along by the water settle out and become the sediment at the bottom of the river.

Sediment in some areas impedes use of tribal fishing access sites and has negative impacts on cold-water refuges and other important habitat. Sedimentation can also impact navigation when it builds up in shipping channels. Areas commonly dredged include the confluence of the Snake and Clearwater Rivers, and other navigation points such as lock approaches and docking areas. The Corps maintains the navigation channel by dredging and by other activities, such as those listed in the Programmatic Sediment Management Plan (Corps 2014) and other documents. Sediment is characterized following applicable guidance and regulations prior to the implementation of dredging projects.

Sediment can carry pollutants. Naturally occurring metals (e.g., mercury) are expected to be present in the sediment, but unnaturally high levels of metals, nutrients, or organic compounds that wash into the river can bind to the sediment and remain at the bottom of the river. These pollutants can be mixed back into the water at a later time when the sediment is disturbed, or they can remain in the river or reservoir and impact aquatic organisms that live in or near the sediment.

Within the Columbia River Basin, sediment quality varies by location. The uppermost end of the system, such as the area near Hungry Horse Dam, tends to have fewer human influences and thus less sediment-based pollution.  As one moves downstream to more populous areas, sediment pollution is more common.  In addition, some reservoirs have known sediment pollution problems related to past industrial discharges from upriver sources. For example, in Lake Roosevelt, an estimated 10 to 14 million tons of slag-related contaminants are can be found in the sediments due to smelter operations. Sediment does not easily wash away from reservoirs, and the quality of the sediment tends to reflect the land uses and past environmental practices of the land users.

General issues throughout the Columbia River Basin include metals, which are particularly high in some reservoirs, and pesticides. Pesticides are generally present in low concentrations, however many of these compounds are toxic to aquatic organisms, bioaccumulate, and persist in the environment for decades. Other notable pollutants found in sediment within the basin include radionuclides, dioxins, and petroleum-based compounds. As with water pollutants, the sediment pollutants reflect the land uses and practices within the basin, including urban development, agriculture, mining, and other industrial activities. In summary, the contaminants of concern in sediment include metals, mercury, PCBs, dioxins, pesticides, and other organic compounds (mostly from human sources). Sediment quality at individual reservoirs, including potential sources of pollutants and historical issues, is discussed at length in separate technical documents that can be found on the CRSO website (https://www.nwd.usace.army.mil/CRSO/Documents/).

### 3.4.3 Environmental Consequences

#### *3.4.3.1 Methodology*

Changes to water and sediment quality for each alternative were assessed using both quantitative (numerical) and qualitative methods. Modeling was used to simulate the effects on water temperature and TDG in the Columbia, Snake, and Clearwater River Systems, while qualitative methods were used to predict effects to other physical, chemical, and biological processes such as dissolved oxygen.

The analysis used the CE-QUAL W2 and Hydraulic Engineering Center River Analysis System software (HEC-RAS) numerical models which are described further below:

- CE-QUAL-W2 model: The CE-QUAL-W2 model (Version 4.2) was used to simulate reservoir water temperature and TDG both by depth and distance up and downstream.
- HEC-RAS model: The HEC-RAS model (Version 5.0.3) was used to simulate up and downstream river (non-reservoir) water temperatures in the Snake, Clearwater, and middle Columbia Rivers.

Portions of the study area were analyzed with the CE-QUAL W2 and HEC-RAS models linked together. This is referred to as the "system model." The portion of the CRSO study area considered in the system model included an area that extended from the Columbia River mainstem at the U.S.-Canada border to Bonneville Dam. In the Snake River Basin, the system model included the North Fork of the Clearwater River from Dworshak Reservoir, the mainstem Clearwater River downstream of Orofino, Idaho, and the Snake River from Anatone, Washington, to the mouth of the Snake River. The system model included the 11 Federal dams in the study area: Grand Coulee, Chief Joseph, Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. It also included five non-CRS projects (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids) on the Columbia River mainstem to more accurately describe the river conditions (Figure 3-107); however, the water quality at the non-CRS dams is not discussed in this section.

The system model required reservoir and river operations data and meteorological data such as wind speed and direction, air temperature, and barometric pressure inputs to predict water quality conditions. The reservoir and river operations data[4] used in the system model included total discharge, spillway and powerhouse operations, miscellaneous discharge, and reservoir/tailwater elevation data.

Water quality modeling in the system model was conducted over a 5-year period (2011 to 2015) to represent a wide range of environmental responses to hydrology (wet, dry, average) and weather conditions (hot, cold, average). These years are represented as the following:

- 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.

- 2012 = AF/LT (average inflow/low temperature),
- 2013 = LF/AT (low flow/average temperature),
- 2014 = AF/AT (average flow/average temperature), and
- 2015 = LF/HT (low flow/high temperature).

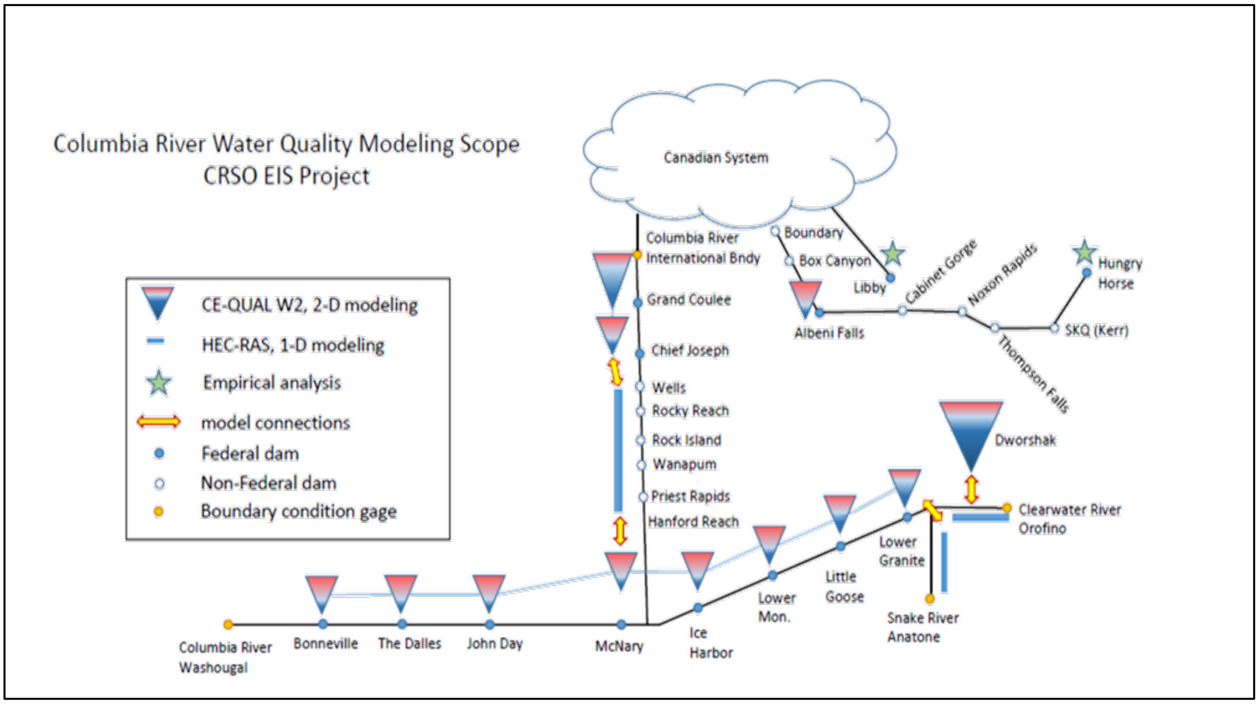



**Figure 3-107. Columbia River System Operations Environmental Impact Statement Water Quality Modeling Framework**

After running the system model, the simulated water temperature and TDG data were compared to state, federal and tribal temperature and TDG standards to quantify the effects associated with each alternative. This information was also used to inform effects to other resources such as anadromous and resident fish (Section 3.5), wildlife (Section 3.6), tribal uses (Section 3.17), and recreation (Section 3.11).

To analyze effects associated with actions at Albeni Falls Dam, the CE-QUAL W2 model was run separately from the system model because the Albeni Falls Dam is located on the Pend Oreille River approximately 100 river miles upstream from where the Pend Oreille River joins the Columbia River. Moreover, downstream of the Albeni Falls Dam, the Pend Oreille River is influenced by two non-Federal U.S. dams and two Canadian dams before flowing into the Columbia River. The Albeni Falls water quality modeling was used to simulate effects from the operation of Albeni Falls Dam, only, and not effects from the operation of non-CRS dams such as Boundary or Box Canyon, which fall outside the scope of this EIS. The Albeni Falls modeling addressed the area that extends from the outlet of Lake Pend Oreille near Sandpoint, Idaho, downstream to Albeni Falls Dam. The model simulated water temperatures, which were compared to state and Federal temperature standards. TDG production at Albeni Falls Dam was addressed qualitatively because a reliable model could not be developed due to a lack of direct relationship between discharge from the dam and TDG.[5]

For the Libby and Hungry Horse Dams, updated and peer-reviewed CE-QUAL W2 models either did not exist or were too outdated to be updated for use in this EIS. Instead, analysis tools that relied on observational data were developed to predict TDG generation from dam operations. The TDG analysis used TDG production equations that were derived from observational data to predict TDG generated under the various flow regimes for each alternative. A qualitative assessment was used to evaluate whether the MOs would likely adversely impact the ability to continue managing downstream water temperatures using the selective withdrawal systems that exist at both Libby and Hungry Horse Dams.

For each of the regions in the study area, sediment quality effects were evaluated qualitatively, using existing field data and information from past studies (white paper; i.e., CH9). There was no overall model describing sediment quality; however, sediment movement information from Section 3.3, *River Mechanics*, and the associated white paper; i.e., CH9 were used to inform the sediment quality analysis. For more information on these models and geomorphology and analysis, refer to Appendix D, *Water and Sediment Quality Appendix*, and Appendix C, *River Mechanics Technical Appendix*.

#### *3.4.3.2 Impact Framework*

A framework was developed to define the overall level of water temperature and TDG impact for each CRSO EIS alternative as compared to the No Action Alternative.  For water temperature, the level of impact (negligible, minor, moderate, or major) was defined based on the absolute change in the maximum and minimum water temperatures as averaged over the 5-year simulation period (2011-2015).  If the absolute change in water temperature between the MO Alternative and No Action Alternative was less than 0.4 degree Fahrenheit, the water temperature impact was considered negligible. If the absolute change in average minimum and maximum values was greater than 0.4 degree Fahrenheit, but less than 2 degrees Fahrenheit , the impact was considered negligible, minor or moderate based on the time of year (season) the impact occurred and whether the impact increased the number of days that State water quality standard (WQS) criteria was not met and by how much.  Absolute water temperature changes of >2 degrees Fahrenheit, or an increase in water temperature WQS exceedances of greater than 10 days, were considered a major impact (Figure 3-108).

For total dissolved gas, the following decision criteria was used to determine level of impact:

- Negligible: <=1% change in the 5-year average maximum TDG as compared to the No Action Alternative.
- Minor: >=1% but <2% change in the 5-year average maximum TDG as compared to the No 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.

- Moderate: >=2% but <3% change in the 5-year average maximum TDG as compared to the No Action Alternative.
- Major: >=3% change in the 5-year average maximum TDG as compared to the No Action Alternative.

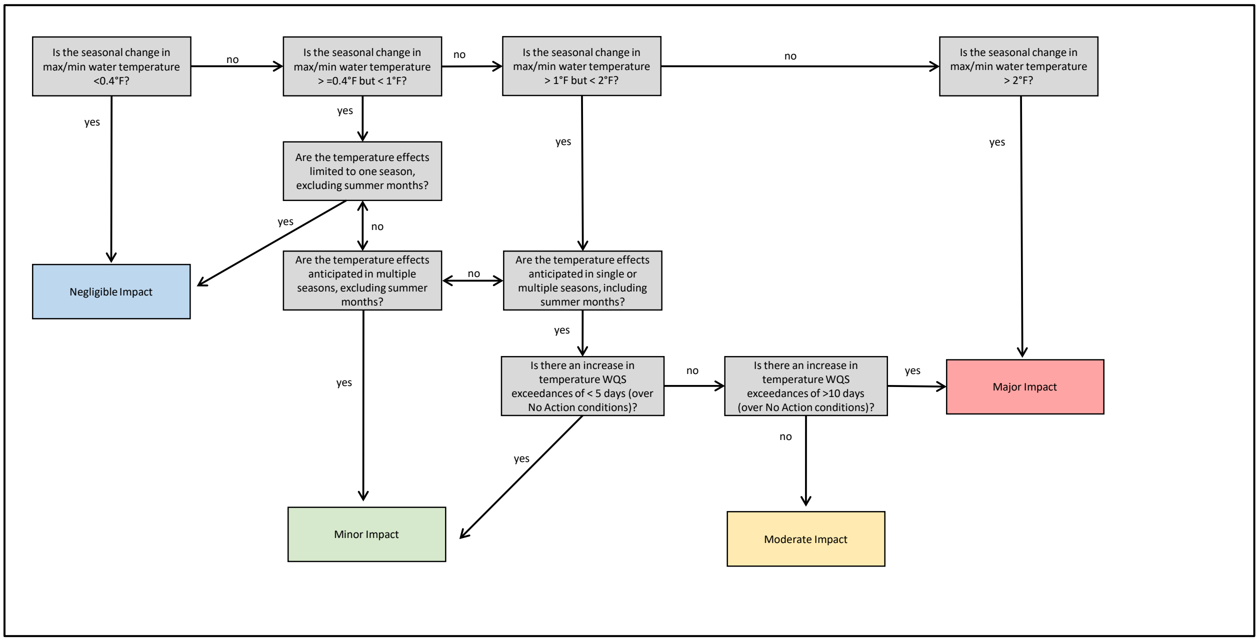



**Figure 3-108. Water Temperature Impact Framework and Decision Criteria**

These descriptors are used to summarize the overall impact of each EIS Alternative as described in the sections below.

For more detailed results, please refer to the Water Quality Technical Appendix D.

#### *3.4.3.3 No Action Alternative*

Water and sediment quality under the No Action Alternative would be expected to continue in a similar manner as that described in Section 3.4.2, *Water Quality Affected Environment*.

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

**Water Quality**

***Water Temperature***

In Region A, the use of the SWS at Hungry Horse and Libby Dams would continue under the No Action Alternative and, therefore, water temperatures at both projects are expected to be similar to those described in the Affected Environment (Section 3.4.2). Water temperatures in Lake Pend Oreille and the Pend Oreille River would remain unchanged and would also reflect conditions as described in the Affected Environment.

#### *Total Dissolved Gas*

TDG often does not meet the state of Montana's standard of 110 percent below Hungry Horse Dam during high-flow years when flow exceeds powerhouse capacity and water is released through the dam outlets known to produce TDG. This is expected to continue under the No Action Alternative in high-flow years. In years that follow a very dry year in which Hungry Horse Reservoir water levels are well below the end of September elevations, minor reductions in TDG would be observed due to the reduced spill associated with lower reservoir water levels. Any spill operations conducted at Libby Dam would continue to cause elevated TDG downstream. Libby Dam is not expected to spill frequently under the No Action Alternative, so downstream TDG saturations are anticipated to typically remain less than 110 percent.

Albeni Falls Dam spill is highly dependent on runoff volumes and, historically, Albeni Falls Dam has spilled most years. Under the No Action Alternative, these spillway operations are expected to continue in a manner similar to that described in the Affected Environment (Section 3.4.2).

#### *Other Physical, Chemical, and Biological Processes*

Under the No Action Alternative, nutrients or pollution would remain relatively low in Hungry Horse Reservoir. If coal production in the Kootenai River watershed above Libby Dam continues to increase, as it has over the past 20 years, this increase will lead to greater selenium and nitrate loadings into Lake Koocanusa and the Kootenai River downstream of Libby Dam. Though separate from the operation of Libby Dam, the continued increase in nitrate loadings to Lake Koocanusa could make the lake susceptible to increased algae blooms including potential nuisance species under the No Action Alternative.

Current water quality conditions of Lake Pend Oreille and the Pend Oreille River are expected to continue under the No Action Alternative. If nutrients continue to increase in the nearshore areas, it is likely that nuisance aquatic growth would further impair beneficial uses in the future.

### Sediment Quality

Similar to water quality, under the No Action Alternative, sediment-related processes and projects would continue to occur much as they do now as described in the Affected Environment (Section 3.4.2).

Sediment accumulation behind the dams in Region A would continue under the No Action Alternative. Sediment that has accumulated behind the dams would remain a source of contamination to benthic and aquatic organisms in Libby Reservoir due to upstream mining activities. No known pollutants exist in Hungry Horse Reservoir or directly downstream of the dam.

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

### Water Quality

#### Water Temperature

Lake Roosevelt at Grand Coulee has relatively short water retention times (i.e., the water does not stay in the reservoir for long) due to the large amount of flow through the reservoir. This short retention time results in water temperatures being fairly uniform across reservoir depths and at the dam's penstock intake depths. Because of the nearly uniform water temperature in the reservoir, there is not a cold water layer from which to draw from during the summer. This results in Grand Coulee Dam releasing the coolest water possible in the summer months, based on constraints for generation reliability, voltage stability, and TDG standards. Lake Roosevelt does, however, exhibit the typical water temperature lag that is commonly seen in impounded waterbodies. The reservoir tends to be cooler in the spring and warmer in the fall as compared to undammed rivers. This pattern would continue in the future under the No Action Alternative.

Chief Joseph Dam is a run-of-river project located downstream of Grand Coulee Dam. Little to no thermal stratification (i.e., different water temperature layers) occurs in Rufus Woods Lake, and water temperatures released from Grand Coulee Dam are passed downstream with little change due to the high flows and short retention time in the reservoir. Under the No Action Alternative, these conditions are expected to continue.

#### *Total Dissolved Gas*

TDG often does not meet state water quality standards at the international border, or downstream of Grand Coulee or Chief Joseph Dams, during high-flow years when a spill occurs. TDG produced by the operation of Grand Coulee and Chief Joseph Dams is expected to remain unchanged and reflect conditions as described in the Affected Environment (Section 3.4.2). Spill would still be necessary when total flows exceed powerhouse capacity or for hydropower (lack of market) reasons. The Chief Joseph spillway would still be equipped with flow deflectors to reduce TDG in the Columbia River. Spill operations at Chief Joseph Dam that are used to manage TDG saturations in the Columbia River are not expected to change under the No Action Alternative.

#### *Other Physical, Chemical, and Biological Processes*

Lake Roosevelt's in-reservoir processes would continue under the No Action Alternative (see Appendix D). The rate of bioaccumulation of contaminants within the reservoir is anticipated to remain relatively unchanged from what is currently observed.

In recent years, there has been an increase in harmful algae blooms in Rufus Woods Lake that are not attributed to the aquaculture facilities. These blooms are a fairly recent water quality issue, which remain unexplained, but are expected to continue in the future under the No Action Alternative.

**Sediment Quality**

Similar to water quality, under the No Action Alternative, sediment-related processes and projects would continue to occur much as they do now, as described in the Affected Environment (Section 3.4.2).

Sediment accumulation behind the dams in Region B would continue under the No Action Alternative. Sediment that has accumulated behind the dams would remain a source of contamination to benthic and aquatic organisms. Some pesticides or other compounds may slowly degrade over time; however, metals and the bulk of organic pollutants would remain in the accumulated sediment. Contaminants of concern in the sediment would continue to include metals, mercury, PCBs, dioxins, pesticides, and other organic compounds (mostly from human sources).

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

**Water Quality**

***Water Temperature***

Dworshak is a deep, cold water reservoir that exhibits strong thermal stratification regardless of the quantity of water entering the reservoir (i.e., runoff year). As such, under the No Action Alternative, sufficient cold water that is less than 52°F is expected to continue to be available to moderate lower Snake River temperatures during the summer (see Appendix D).

Water temperatures at the lower Snake River projects as described in Section 3.4.2 would continue under the No Action Alternative. As noted earlier, historical temperatures in the lower Snake River Basin prior to the construction of the lower Snake River dams and the Hells Canyon Complex show that temperatures in the free-flowing lower Snake River often exceeded 68°F (20°C) in July and August and occasionally exceeded 25°C. The effects of the Dworshak Dam summer cool water releases are expected to continue to influence water temperatures in the lower Snake River. The most noticeable effect of the cool water releases would be noted at Lower Granite Reservoir where water temperature stratification is expected to occur during the summer and tailwater temperatures would usually be held at less than 68°F during the summer (see Appendix D). The cooling effect from the Dworshak water releases would diminish at each successive downstream reservoir after Lower Granite and the frequency of water temperatures exceeding water temperature standards would increase downstream of Lower Granite Dam. Winter water temperatures would continue to be in the low 30°F range, with some surface icing during colder winters.

#### *Total Dissolved Gas*

Under the No Action Alternative, TDG is anticipated to be less than 110 percent the majority of the time below Dworshak Dam, although short-term exceptions would likely occur when flows exceed powerhouse capacity.

The four lower Snake River dams are run-of-river projects, and TDG production is highly related to runoff volume. Excursions above the WQSs in place in 2016 (115 percent forebay and 120 percent tailwater) are expected to continue during the fish spill season (April through August) at a frequency of that observed in recent years.  Additionally, because expressed TDG saturation is temperature dependent, elevated TDG saturation would also be expected to occur during low-flow conditions when the air temperatures are high.

#### *Other Physical, Chemical, and Biological Processes*

Dworshak Reservoir nutrient fertilization occurs annually and is expected to continue under the No Action Alternative. As the program continues, additional data should help identify whether the observed shifts in water quality are due to the fertilization program or changes related to the inflows, natural aging of the lake, or other unidentified causes.

The lower Snake River contains a variety of human-sourced compounds, including metals and organic compounds. Continued pollutant and nutrient loading is expected due to farming activities, industry, and urban and agricultural runoff. In addition, models suggest that the current moderate to high levels of nutrients (i.e., mesotrophic to eutrophic conditions) in the lower Snake River reservoirs is unlikely to change under the No Action Alternative. Thus, it is expected that the current water quality impairments would continue under the No Action Alternative.

### Sediment Quality

Sediment-related processes and projects would continue to occur in a similar manner as described above for Region B. Additionally, sediment management activities in the lower Snake River (as described in the Programmatic Sediment Management Plan (Corps 2014) and other documents) would continue as currently planned under the No Action Alternative. Areas that historically have required dredging (lock chamber approaches, harbor and port berthing areas and entrances) would still experience shoaling (buildup of sediment in shallow areas). The Federal Navigation Channel (FNC) and private dockface/berthing area dredging to maintain navigation would still occur.

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

### Water Quality

#### *Water Temperature*

The four lower Columbia River reservoirs (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no water temperature stratification during the summer months. This would largely be due to the short time water is in the reservoirs and water mixing[6] that occurs in the reservoirs. Exceedances of water temperature standards in Region D occur during the summer under a range of river and meteorological conditions and would be expected to continue to occur under the No Action Alternative (see Appendix D).

#### *Total Dissolved Gas*

The lower Columbia River dams in Region D are operated as run-of-river projects (albeit John Day has a small amount of storage), and TDG production is highly related to runoff volume. A similar frequency of TDG exceedances above the WQS in place in 2016 (115 percent forebay and 120 percent tailwater) are expected to continue to occur during the juvenile fish passage spill season under the No Action Alternative. Additionally, because TDG saturation is temperature dependent, elevated TDG would be expected to occur during low-flow conditions when the air temperatures are high.

#### *Other Physical, Chemical, and Biological Processes*

The lower Columbia River contains a variety of human-sourced compounds, including metals and organic compounds. Continued pollutant and nutrient loading is expected due to farming activities, industry, and urban and agricultural runoff. In addition, data suggests that the moderate to high levels of nutrients (i.e., mesotrophic to eutrophic conditions) in these reservoirs is unlikely to change under the No Action Alternative. Thus, it is expected that the current water quality impairments in the lower Columbia River would continue under the No Action Alternative.

### Sediment Quality

Sediment-related processes and projects would continue to occur in a similar manner as that described above for Region C.

## SUMMARY OF EFFECTS

Water and sediment quality under the No Action Alternative would be expected to continue in 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).

Although the effects of the No Action Alternative differ across the various projects in terms of water and sediment quality, they can generally be categorized as follows.

In Region A, TDG does not always meet the state of Montana's standard of 110 percent below Hungry Horse Dam during high-flow years when flow exceeds powerhouse capacity and water is released through the dam outlets known to produce TDG. This is expected to continue under the No Action Alternative in high-flow years. Any spill operations conducted at Libby Dam would continue to cause elevated TDG downstream. Increases in nitrate loadings to Lake Koocanusa and the Kootenai River could lead to increased algal blooms and associated nuisance species. Contaminated sediment accumulation behind Libby Dam in Region A would continue under the No Action Alternative.

In Region B, water temperature lags associated with Lake Roosevelt would continue, and water temperatures released from Grand Coulee Dam would be passed downstream and through Lake Rufus Woods with little change due to high flows and short retention times. TDG produced by the operation of Grand Coulee and Chief Joseph Dams is expected to remain unchanged. Algae blooms in Rufus Woods Lake would be expected to continue.

In Region C, thermal stratification at Dworshak reservoir and the release of cold water to moderate lower Snake River temperatures would be expected to continue. TDG would be anticipated to be less than 110 percent the majority of the time below Dworshak Dam, while a similar frequency of TDG exceedances above WQS in place in 2016 (115 percent forebay and 120 percent tailwater) are expected to continue in the lower Snake River. Continued pollutant and nutrient loading is expected due to farming, industry, and urban and agricultural runoff in the lower Snake River.

In Region D, little to no water temperature stratification would occur during the summer months, and exceedances of water temperature standards would continue under a range of river and meteorological conditions. Similar frequencies of TDG exceedances above current standards are expected to continue during the juvenile fish spill season (April through August). Continued pollutant and nutrient loading is expected due to farming, industry, and urban and agricultural runoff.

### *3.4.3.4 Multiple Objective Alternative 1*

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

**Water Quality**

***Water Temperature***

In general, the water temperature response at the Libby and Hungry Horse Dams are expected to be similar to the No Action Alternative. However, slight changes in water temperatures downstream of Libby Dam could occur due to the *December Libby Target Elevation* and *Modified Draft at Libby* measures. With these measures, water temperatures downstream of

Libby Dam could be warmer in the winter and colder in the early spring as compared to the No Action Alternative.

There are no changes to operations expected at Albeni Falls Dam under MO1, so the temperature conditions in Lake Pend Oreille and the Pend Oreille River are expected to remain unchanged under MO1 and reflect conditions as described in the No Action Alternative.

***Total Dissolved Gas***

In general, MO1 would have little to no impact on TDG conditions below Libby, Hungry Horse, and Albeni Falls Dams as compared to the No Action Alternative.

TDG below Hungry Horse Dam under MO1 is expected to be relatively similar to the No Action Alternative in most years. The winter and spring operations at Hungry Horse Dam are not specifically targeted by any of the MO1 measures, but due to changes in reservoir elevations at the end of September from *the Hungry Horse Additional Water Supply* measure and the *Sliding Scale at Libby and Hungry Horse* measure, winter and spring reservoir elevations and outflows would be impacted. In the years that follow a very dry year, in which Hungry Horse Reservoir water levels are well below the summer flow augmentation elevation objectives at the end of September, minor reductions in TDG would be observed due to the reduced outflow and spill the following spring associated with lower reservoir water levels.

Libby Dam is operated to minimize spill. Under MO1, Libby Dam's draft and refill operations would be modified, resulting in a minor increase in spill compared to the No Action Alternative. For the 80-year period from 1928 to 2008, model results predict 6 years with spill under MO1 compared to 2 years when spill would occur for the No Action Alternative. In those years identified as having spill at Libby Dam, the model predicts 35 days with TDG exceeding 110 percent for MO1 versus only 8 days with TDG exceedances under the No Action Alternative. Regardless, Libby Dam is not expected to spill frequently under MO1, so downstream TDG saturations should remain less than 110 percent the majority of time.

Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills most years. Because there is no change in Albeni Falls Dam operations between MO1 and the No Action Alternative, spillway operations and TDG conditions under MO1 are expected to remain unchanged.

***Other Physical, Chemical, and Biological Processes***

Negligible impacts to the physical, chemical, or biological processes at Hungry Horse Reservoir and the South Fork Flathead River downstream of the dam, are expected as compared to the No Action Alternative. Although the operational measures *Hungry Horse Additional Water Supply* and *the Sliding Scale at Libby and Hungry Horse* could result in deeper reservoir drawdowns, stratification that would influence nutrient levels in Hungry Horse Reservoir are not expected to change. There may be some reductions to primary and secondary productivity in the reservoir due to changes in outflows and storage, but effects would be negligible as compared to the No Action Alternative.

MO1 would result in changes to water levels in Lake Koocanusa that may impact physical, chemical, and biological water quality parameters when compared to existing conditions and the No Action Alternative. Parameters of concern in Lake Koocanusa that may be altered by MO1 include changes to nutrients (such as phosphorus and nitrogen), selenium, and phytoplankton. Although unrelated specifically to MO1, coal production in the Kootenai River watershed above Libby Dam may continue to increase, as it has over the past 20 years. This increase, together with changes in reservoir elevations and the amount of time water spends in the reservoir under MO1, may lead to greater quantities of selenium and nitrate in Lake Koocanusa and the Kootenai River downstream of Libby Dam. The shorter residence time (amount of time that water stays in the reservoir) may also allow phosphorus to move farther down reservoir before settling out or transforming. This increase in nutrients available in the reservoir could make the lake more susceptible to increased phytoplankton blooms including potentially toxic species under MO1.

Water quality conditions of Lake Pend Oreille and the Pend Oreille River described for the affected environment and the No Action Alternative are expected to continue under MO1.

**Sediment Quality**

Operational changes at Libby and Hungry Horse Dams under MO1 are not expected to affect sediment movement downstream in the Kootenai and Flathead Rivers, respectively. MO1 would not impact Albeni Falls Dam operations and would not affect sediment sources or movement.

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

**Water Quality**

***Water Temperature***

The water temperature in Lake Roosevelt would not likely be affected by upstream flow changes or by the five operational measures (*Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Grand Coulee Maintenance Operations, Winter System FRM Space,* and *Lake Roosevelt Additional Water Supply*) called for under MO1.

For Columbia River temperatures downstream of Grand Coulee Dam, model results suggest there would be a negligible change in water temperatures, on average. The number of days that water temperatures would exceed Washington State WQSs would be reduced by 1 day per year, on average. Changes to Grand Coulee Dam outflows would be carried through Rufus Woods Lake, Chief Joseph Dam, and downstream. These flow changes are relatively small and would result in a negligible change in Rufus Woods Lake elevations when compared to the No

Action Alternative. As such, Chief Joseph Dam tailwater temperatures under MO1 would be similar to the No Action Alternative.

### *Total Dissolved Gas*

Downstream of Grand Coulee Dam, major reductions in TDG, as compared to the No Action Alternative, would occur due to the MO1 measures that call on more operational flexibility for FRM (*Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, *Grand Coulee Maintenance Operations*, and *Winter System FRM Space*) and the water supply measure (*Lake Roosevelt Additional Water Supply*). The major maintenance measure (*Grand Coulee Maintenance Operations*), which is expected to temporarily reduce the powerhouse capacity of Grand Coulee Dam and increase the magnitude of spill and TDG in some situations, was balanced by improvements to TDG associated with the other Grand Coulee measures. TDG effects anticipated at Grand Coulee would be carried downstream of Chief Joseph Dam and Reservoir. During high flow years, the spillway deflectors at Chief Joseph Dam would provide reductions (degassing) of elevated TDG levels generated from upstream Canadian dam and Grand Coulee Dam operations. TDG effects downstream of Chief Joseph Dam under MO1 are negligible.

### *Other Physical, Chemical, and Biological Processes*

Qualitative analysis suggests that, when compared to the No Action Alternative, MO1 could have minor effects to physical, chemical, and biological processes in Lake Roosevelt. The slower drawdown from the *Planned Draft Rate at Grand Coulee* measure could provide minor reductions in local landslides and associated high turbidity, and thereby improve water quality. However, water level fluctuations in the reservoir (due to the *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, and *Winter System FRM Spa*ce measures) may increase methylmercury in the waterbody. The MO1 measures would not change the number of times portions of the reservoir banks and margins are covered with water (inundated), but the MO1 measures would result in earlier and longer exposure of sediments. This longer sediment exposure may increase the amount of mercury that is converted to methylmercury upon rewatering the area. Methylmercury is the more toxic form of mercury that bioaccumulates in fish tissue. Minor changes to water retention times passing through the reservoir from February through July are not expected to result in changes to algae blooms, pH, or dissolved oxygen conditions. No additional physical, chemical, or biological water quality effects are expected to occur in the Columbia River immediately below Grand Coulee Dam.

Chief Joseph Dam and Rufus Woods Lake elevations and flows under MO1 are predicted to be similar to the No Action Alternative. As such, the water quality of Rufus Woods Lake under MO1 would be similar to the No Action Alternative. The harmful algae blooms described for the affected environment and the No Action Alternative would be expected to continue in the future under MO1.

#### Sediment Quality

Minor increases in the mobilization of sediment and shoreline erosion is expected within Lake Roosevelt due to changes in elevations under MO1 from the *Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Grand Coulee Maintenance Operations, Winter System FRM Space,* and *Lake Roosevelt Additional Water Supply* measures. However, it is not anticipated that additional sediment would pass the dam; expected effects would occur within the reservoir. In comparison to the No Action Alternative, MO1 flow changes at Chief Joseph Dam would be minor, and no effects to sediment sources or movement would be expected.

### REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

#### Water Quality

##### *Water Temperature*

Under MO1, Dworshak Reservoir would continue to thermally stratify during the summer, and outflow water temperatures would remain less than the Idaho State water quality standard of 55.4°F. Water temperatures in the lower Snake River would increase during August, due to the *Modified Dworshak Summer Draft* measure. Under MO1, cool water would be discharged into the lower Snake River from June 21 to August 1. During August, total Dworshak outflows would be reduced to preserve cold water for release again in September. This modified Dworshak operation would result in a moderate increase in water temperatures in the lower Snake River, on average. It is not anticipated that fish ladder water temperature improvements at Lower Monumental and Ice Harbor Dams (*Lower Snake Ladder Pumps*) would have any meaningful impact to downstream river water temperatures. These structural changes would be anticipated to effect fish ladder conditions only.

##### *Total Dissolved Gas*

Implementing MO1 would lead to negligible changes to TDG saturation below Dworshak Dam for most flow and temperature conditions. There are two measures within MO1 that would modify juvenile fish passage spill operations in the lower Snake River; the *Block Spill Test (Base + 120/115%) Measure* and the *Summer Spill Stop Trigger.* The *Block Spill Test* calls for a spill test to evaluate the latent mortality hypothesis; spill operations switch between performance (base) spill and a test spill operation within a given season. The *Summer Spill Stop Trigger* calls for the early end to summer juvenile fish passage spill operations at the lower Snake River projects. Ending dates vary from August 6 to 21, depending on the dam. Due to the within-season switch between operations at the dams, in conjunction with an assumed higher amount of lack of load/lack of market spill, model results showed a negligible difference in TDG levels under MO1, even with these operational measures, as compared to the No Action Alternative.

#### *Other Physical, Chemical, and Biological Processes*

Having water stay longer in Dworshak Reservoir during August under the *Modified Dworshak Summer Draft Measure* could lead to additional blue-green algae growth. However, liquid fertilizer is currently added (and would be expected to continue) to the reservoir to manage the nitrogen to phosphorus ratio (nutrient balance). The continuation of the nutrient balancing would be expected to prevent the formation of hazardous algal blooms as a result in the change to Dworshak operation under MO1.

Increased water temperatures (as described above), along with higher concentrations of soluble nutrients and a longer time water stays in reservoirs in the lower Snake River during August, would likely foster additional growth of cyanobacteria (blue-green algae) in swim areas and boat basins.

### Sediment Quality

MO1 includes structural changes aimed at improving juvenile fish passage in Region C; these proposed measures would not affect sediment sources or movement because they do not change the overall flow range experienced in the river, and the measures would not result in disturbance of the sediment held deep within the reservoir. The proposed operational changes generally have a goal of improving flexibility in operation and of improving in-stream (flow and temperature) conditions for fish; changing the timing of operational flows or the temperature characteristics would not affect sediment sources. MO1 is not expected to affect land use throughout the basin, including upland recreation, FRM, agricultural, timber, or mining activities, and is not expected to change population growth patterns in the area of any of the affected reservoirs. Overall, MO1 is not expected to affect sediment movement within Region C.

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

### Water Quality

#### *Water Temperature*

Under MO1 and as with the No Action Alternative, the four lower Columbia River reservoirs (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no water temperature stratification during the summer months largely due to the time water is in the reservoirs and water mixing that occurs in the reservoirs. Maximum tailwater temperatures and the frequency of water temperature standard exceedances would be similar for MO1 and the No Action Alternative over a range of river and meteorological conditions; negligible effects are anticipated.

#### *Total Dissolved Gas*

Similar to that described for the lower Snake River projects in Region C, the measures within MO1 that modify spill would have a negligible effect on TDG levels under MO1 as compared to the No Action Alternative for the lower Columbia River projects.

#### *Other Physical, Chemical, and Biological Processes*

For Region D, MO1 would have no change on the physical, chemical, or biological water quality impairments.

### Sediment Quality

Overall, sediment quality within Region D would change little from the No Action Alternative as the structural measures, operational changes, nor would land use under MO1 impact sediment sources or movement.

## SUMMARY OF EFFECTS

Although the effects of MO1 differ across the various projects in terms of water and sediment quality, they can generally be categorized as follows:

In Region A, MO1 is expected to have negligible to minor effects to water temperatures and TDG conditions at the projects when compared to what would occur under the No Action Alternative. There would be a minor increase in spill and associated TDG levels at Libby Dam due to the project's draft and refill operations. Minimal changes to the physical, chemical, or biological processes in most locations in Region A would occur.  Elevated concentrations of selenium and nitrate-nitrogen in Lake Koocanusa and the Kootenai River downstream may occur due to the increased reservoir elevations that may concentrate these contaminants. Lastly, MO1 would not impact turbidity or sediment concentrations in the region. Overall, these effects are expected to be negligible to minor.

In Region B, MO1 is expected to have negligible effects on water temperatures when compared to the No Action Alternative. Major reductions in TDG would occur downstream of Grand Coulee due to the *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, *Grand Coulee Maintenance Operations*, and *Winter System FRM Space* and *Lake Roosevelt Additional Water Supply* measures. Slight increases in mercury solubility in Lake Roosevelt may occur, but there would be little to no additional changes compared to the No Action Alternative to the physical, chemical, and biological processes elsewhere. The minor additional mobilization of sediment is expected to occur in Lake Roosevelt, but no additional changes to sediment quality are anticipated. Overall, these effects are expected to be negligible to minor. Negligible impacts are expected in Lake Rufus Woods or downstream of Chief Joseph Dam.

In Region C, MO1 is expected to increase the number of days that water temperatures would exceed Washington State water quality standards in the lower Snake River due to the *Modified Dworshak Summer Draft* measure.  Major impacts would be expected in the Lower Granite tailwater with an additional 18 days of exceedances per year on average, as compared to the No Action Alternative. Negligible impacts would be expected in the Ice Harbor tailwater with an additional 5 days of exceedances per year, on average as compared to the No Action Alternative. Increased water temperatures may result in additional growth of blue-green algae in the region. Little to no changes in TDG concentrations and sediment movement would occur. Overall, the effects to water quality would be moderate for water temperature and negligible to minor for TDG and other water quality parameters.

In Region D, MO1 is expected to result in little to no change to water temperatures, TDG, sediment quality, or other water quality parameters when compared to the No Action Alternative. These effects are expected to be negligible.

For further details, please refer to the Water Quality Technical Appendix D.

#### *3.4.3.5 Multiple Objective Alternative 2*

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

**Water Quality**

***Water Temperature***

Under MO2, the SWSs at Hungry Horse and Libby Dams would continue to be operational. However, thermal stratification must be present in the forebay for the SWSs to achieve temperatures as close as possible to downstream water temperature objectives, critical for resident fish species. The onset of thermal stratification is difficult to predict and can vary from year to year due to reasons such as inflow volumes, inflow temperatures, reservoir drawdown elevation, discharge volumes, and weather conditions. Historical temperature data suggests that holding the reservoir water levels higher in the winter results in colder reservoir water temperatures and difficulty for the SWSs to achieve desired water temperatures the following spring/early summer.

When Libby and Hungry Horse Reservoirs are drafted deeper, the reservoir volume is less, thereby allowing for greater warming in the spring and summer from warmer inflows and warming air temperatures. Under MO2, lower reservoir elevations are anticipated due to the *Slightly Deeper Draft for Hydropower* measure and would likely be substantial enough to result in a change in Lake Koocanusa and Hungry Horse Reservoir water temperatures and thermal stratification as compared to the No Action Alternative. These lower reservoir elevations are likely to result in slightly warmer reservoir temperatures and earlier thermal stratification during the spring and summer resulting in a greater ability for the SWSs to achieve downstream temperatures when compared to the No Action Alternative.

Downstream of Libby Dam, higher November and December outflows may delay the natural cooling of the Kootenai River downstream of the dam. The higher outflows in November and December are caused by the combination of the *Slightly Deeper Draft for Hydropower* measure with the *December Libby Target Elevation* measure. When combined, these measures result in a reservoir elevation of 2,400 feet NGVD29. This deeper draft to 2,400 feet NGVD29 at the end of December, and the subsequent reservoir levels through the winter, however, may allow for the reservoir to warm earlier in the spring, providing for earlier (and beneficial) warming to water temperatures downstream of the dam.

Operations specific to Albeni Falls would change little under MO2 as compared to the No Action Alternative. However, upstream flow changes, such as those called for under MO2 at Hungry Horse Dam, would result in flow changes in the Flathead River that would be evident downstream through the Pend Oreille Basin. These operational changes would result in minor temperature changes downstream of Albeni Falls Dam, ranging from a decrease of about 0.9 degree Fahrenheit to an increase of about 2.7 degrees Fahrenheit , with the greatest differences occurring during the winter months (January/February).

***Total Dissolved Gas***

MO2 would modify Libby Dam's drawdown and refill operations, resulting in a small increase in spill compared to the No Action Alternative. For the 80-year period from 1928 to 2008, model results predict that spill would occur in 6 years under MO2 versus only occurring in 2 years for the No Action Alternative. In those spill years, MO2 would have 27 days with TDG exceeding 110 percent while only 8 days would exceed the TDG standards under the No Action Alternative. Regardless, Libby Dam is not expected to spill frequently under MO2, so downstream TDG saturations should remain less than 110 percent the majority of time.

The *Slightly Deeper Draft for Hydropower* measure allows for greater operational flexibility and would result in deeper winter drawdowns at Hungry Horse Reservoir. This, in turn, would reduce spring outflows and spill in some cases. As a result, the number of days that TDG below the dam would be greater than 110 percent under MO2 is expected to be lower than the No Action Alternative in most years.

Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills most years. Because there are little changes in Albeni Falls Dam operations between MO2 and the No Action Alternative, spillway operations under MO2 are expected to remain unchanged.

***Other Physical, Chemical, and Biological Processes***

The modified operations under MO2 would result in changes in the drafting depth, water elevations, and retention times of Lake Koocanusa and Hungry Horse Reservoir. This could lead to higher flushing rates and reductions in primary and secondary productivity in the reservoirs. Water quality chemical and biological parameters of concern in Lake Koocanusa that may be impacted by MO2's shorter residence times include nutrients such as phosphorus and nitrogen, suspended sediments, metals such as selenium, and phytoplankton.

Water quality conditions of Lake Pend Oreille and the Pend Oreille River described for the affected environment and the No Action Alternative are expected to continue under MO2.

**Sediment Quality**

MO2 includes operational changes that would result in water level changes at some reservoirs. These changes would have little overall effect on sediment within Region A. Additional shoreline erosion could occur at some reservoirs that have large water elevation fluctuations; however, the sediment that erodes would be trapped within the reservoirs and would not move downstream. MO2 is not expected to affect land use throughout the basin, including upland recreation, FRM, agricultural, timber, or mining activities, and it is not expected to change population growth patterns in the area of any of the affected reservoir. The contaminants of concern in the sediment are expected to remain the same. Overall, MO2 is expected to have little impact on sediment conditions within Region A in comparison to the No Action Alternative.

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

**Water Quality**

***Water Temperature***

The Grand Coulee Dam area, comprised of Lake Roosevelt above the dam and the Columbia River below, are affected by five operational measures (*Slightly Deeper Draft for Hydropower, Update System FRM Calculation, Planned Draft Rate at Grand Coulee, Grand Coulee Maintenance Operations, Winter System FRM Space*).  These measures would result in an earlier and sometimes deeper drawdown of Lake Roosevelt and changes to inflow due to changes in operations at the upstream projects. Many of the measures would be implemented in the winter when the reservoir is nearly the same temperature (i.e., isothermal) so downstream temperatures during the winter would not be affected. The carry-over effects from these measures, however, may reduce the cold water mass that tends to cool inflowing water from upstream sources in the spring and early summer. This could result in minor warming in the spring and early summer, especially in LF/HT years (see Section 3.4.3.1 for definitions). Overall, MO2 is expected to have negligible effects on water temperature.

Flow changes observed at Grand Coulee Dam would move downstream through Rufus Woods Lake and Chief Joseph Dam. Water temperatures under MO2 at Chief Joseph Dam tailwater would be similar to, or slightly cooler than, the No Action Alternative with the majority of temperature differences in the ±1 to 2 degrees Fahrenheit range. However, for the AF/AT and LF/HT scenarios (see Section 3.4.3.1 for definitions), spring and early summer water temperatures would be 1 to 2 degrees Fahrenheit warmer under MO2. Tailwater temperatures under MO2 are predicted to exceed the Washington State water quality standard of 63.5°F, as measured by the 7-day average of the daily maximum temperature throughout the months of August and September; these exceedances occur under No Action as well. In general, MO2 water temperature changes at Chief Joseph Dam would be negligible.

#### *Total Dissolved Gas*

The *Grand Coulee Maintenance Operation* measure, in isolation, could result in substantial increases in spill and TDG, and in some cases, produce TDG in excess of 130 percent; however, this effect is largely offset in the spring and early summer by other measures, such as the *Slightly Deeper Draft for Hydropower* measure that would result in lower reservoir elevations in late winter/early spring. Compared to the No Action Alternative, MO2 results in a reduction in TDG, particularly in May and June, in the Columbia River below Grand Coulee Dam. MO2 model results indicate that TDG would decrease, particularly in average flow years, from May 1 to mid-June by 5 percent to 10 percent. This effect is considered a major reduction using the logic presented in Section 3.4.3.2.

At Chief Joseph Dam, forebay and tailwater TDG saturations are predicted to be similar to or slightly less than the No Action Alternative under MO2 for a wide range of flow and air temperature conditions. Overall TDG impacts under MO2, as compared to the No Action Alternative, are negligible.

#### *Other Physical, Chemical, and Biological Processes*

At Grand Coulee, operational measures including the *Winter System FRM Space, Deeper Draft for Hydropower*, and the influence from upstream projects would result in an increase in outflows from November to January. In January through March, the *Planned Draft Rate at Grand Coulee* would likely cause Lake Roosevelt to be drafted more slowly in some cases, potentially reducing local landslides (which can cause turbidity) and thereby improve water quality. However, earlier and deeper reservoir drawdowns at Grand Coulee could result in the longer duration and exposure of reservoir shoreline sediment and increase the potential for mercury solubility in the reservoir water (although the measures would not change the number of occurrences of repeated inundation and exposure of sediment in comparison to the No Action Alternative). Increased exposure has the potential to increase mercury methylation rates, which could lead to greater buildup of mercury quantities in aquatic organisms (i.e., bioaccumulation) (Willacker 2016), among other potential contributing factors. No notable effects are likely to occur in the Columbia River immediately below Grand Coulee Dam.

Chief Joseph Dam and Rufus Woods Lake elevations and flows under MO2 are predicted to be similar to the No Action Alternative. As such, the water quality of Rufus Woods Lake under MO2 would be similar to the No Action Alternative. The harmful algae blooms described for the affected environment and the No Action Alternative would be expected to continue in the future under MO2.

### Sediment Quality

Similar to that described for Region A, MO2 includes operational changes that would result in water level changes at some reservoirs, but the changes would have little overall effect on sediment within Region B. Overall, MO2 is expected to have little impact on sediment conditions within Region B.

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Water Quality

#### *Water Temperature*

Deeper drawdowns of Dworshak Reservoir from the *Slightly Deeper Draft for Hydropower* measure, ranging from 12 to 38 feet in the spring, could lead to slower warming of the surface waters because the smaller surface area would result in less warming by the sun in the early spring. Near-full pool would be reached by July, and thermal stratification for the remainder of the year would not change. Average outflow temperatures would be approximately 0.8 to 1.6degrees Fahrenheit warmer in May, June, and July during AF/AT conditions (see Section 3.4.3.1 for definitions). Mean monthly temperature changes for April through September for the other flow and weather conditions modeled would range from -0.5 to 0.6 degree Fahrenheit. However, maximum temperatures would remain less than 52°F throughout the year, and overall water temperature effects downstream of Dworshak Dam under MO2 would be negligible using the logic presented in Section 3.4.3.2.

MO2 water temperatures in the lower Snake River would result in moderate to minor changes as modeled, compared to the No Action Alternative. Under MO2, ResSim modeling assumptions did not represent the intended operations and instead showed the reservoir would have a decreased refill probability, refilling to within 0.5 feet of the normal full reservoir elevation in about 48 percent of years.  It is likely that in real-time operations, the refill probability for Dworshak Reservoir under MO2 would be higher than shown in modeled results, and more closely aligned to the No Action Alternative. Therefore, effects to water temperatures are considered negligible in Region C.

#### *Total Dissolved Gas*

TDG saturation downstream of Dworshak Dam would remain below 110 percent for most of the year, with a few exceptions. Some increases in downstream TDG occurred in the modeling results during high-flow years due to the modeling assumption that increased outflow in the spring. The spring modeling assumption did not represent the desired operation as defined in the *Slightly Deeper Draft for Hydropower* measure. In actual operations, spill would be consistent with water quality criteria, and these impacts would be avoided, when possible, during implementation of this measure. Overall effects are anticipated to be negligible for TDG.

The *Spill to Near 110 Percent TDG* measure limits juvenile fish passage spill at the lower Snake and Columbia dams to 110 percent TDG as measured in-river, including tailraces and downstream forebays except when higher minimum spill levels are required for powerhouse surface passage routes, for spillway weirs, and/or for adult attraction. Additionally, spill during high flow and flood events would not be restricted to a cap of 110 percent TDG, but rather set to levels necessary for safety. Lack-of-market spill would also continue, and would follow the spill priority list. TDG in the lower Snake River downstream of Lower Granite Dam would be greater than 110 percent from April through July during most flow and meteorological conditions due to lack-of-turbine spill and/or spill for lack-of-market. Maximum TDG values would still exceed 120 and 125 percent during May, June, and July. However, because spill for juvenile fish passage would no longer occur during August under MO2, there would be a minor decrease in the amount of time that TDG levels exceeded 110 percent in August. Overall impacts to TDG in the lower Snake River under MO2 would range from minor to negligible.

***Other Physical, Chemical, and Biological Processes***

The lower water elevation of the Dworshak Reservoir from April through June would result in a smaller surface area and consequently slower warming of the surface by the sun. Additionally, shallower water depths at the upper end of the reservoir would lead to faster water travel times and delayed primary production.

Water quality conditions, as described for the affected environment and the No Action Alternative, are expected to continue under MO2 for the lower Snake River.

**Sediment Quality**

Similar to that described for Region A, MO2 includes operational changes that would result in water level changes at some reservoirs, but the changes would have little overall effect on sediment within Region C for the same reasons discussed above in the Region A discussion under MO2.

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

**Water Quality**

***Water Temperature***

Under MO2 and as with No Action Alternative, the four lower Columbia River reservoirs (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no temperature stratification during the summer months largely due to the time water is in the reservoirs and water mixing that would occur in the reservoirs. Maximum tailwater temperatures and the frequency of water temperature standard exceedances would be similar for MO2 and the No Action Alternative over a range of river and weather conditions. Impacts are expected to be negligible.

***Total Dissolved Gas***

MO2 model results generally show a decrease in forebay and tailwater TDG saturations and in the frequency of exceedances of current state TDG standards of 110 percent as compared to the No Action Alternative. MO2 effects on TDG would be minor at McNary and John Day Dams, moderate at The Dalles Dam, and negligible at Bonneville Dam based on the logic presented in Section 3.4.3.2.

***Other Physical, Chemical, and Biological Processes***

Water quality conditions, as described for the affected environment and the No Action Alternative, are expected to continue under MO2 for the lower Columbia River.

**Sediment Quality**

Overall, MO2 is expected to have little impact on sediment conditions within Region D and would be similar to the No Action Alternative.

**SUMMARY OF EFFECTS**

Although the effects of MO2 differ across the various projects in terms of water quality, they can generally be categorized as follows.

In Region A, MO2 is expected to result in a greater ability for the selective withdrawal system at Lake Koocanusa and Hungry Horse Reservoir to achieve downstream temperature objectives, compared to the No Action Alternative. In the Albeni Falls reservoir, there would be a small water temperature change ranging from about a 0.9 degree Fahrenheit decrease to an increase of about 2.7 degree Fahrenheit. The small increase in spill at Libby Dam would result in a small increase in the number of days with TDG exceeding 110 percent. Hungry Horse Dam would have fewer days exceeding 110 percent TDG compared to the No Action Alternative, and Albeni Falls TDG levels would remain the same. MO2 may result in some reductions to productivity in Hungry Horse and Libby Reservoirs, but the alternative would not impact turbidity or sediment concentrations in the region. Overall, these effects are expected to be negligible to minor.

In Region B, MO2 is expected to result in slight warming in the spring and early summer under certain flow and air temperature conditions, but in general water temperature effects are negligible. TDG would decrease at Grand Coulee, particularly in average flow years, by 5 to 10 percent. TDG effects downstream of Chief Joseph Dam are negligible. There may be some additional mercury mobilization in Lake Roosevelt, but no additional physical, chemical, or biological water quality parameters are anticipated to change from the No Action Alternative.

In Region C, MO2 is expected to result in negligible water temperature effects. The frequency when TDG would exceed 110 percent would decrease in August in the lower Snake River due to reduced spill for downstream fish passage. All other water quality conditions would be similar to those under the No Action Alternative. Overall, water quality effects in Region C under MO2 are anticipated to be minor to negligible.

In Region D, water temperatures would be similar to the No Action Alternative. TDG saturations and the frequency of exceeding the state TDG water quality standards would decrease under MO2. All other water quality parameters are anticipated to be similar to the No Action Alternative. Overall, there would be a negligible impact to most water quality parameters and a minor to moderate reductions in TDG conditions.

For further details, please refer to the Water Quality Technical Appendix D.

#### *3.4.3.6 Multiple Objective Alternative 3*

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

**Water Quality**

***Water Temperature***

Under MO3, the SWSs at Hungry Horse and Libby would continue to be operational and therefore, water temperatures management at both projects would continue as that described in the No Action Alternative. Downstream of Libby Dam, higher November and December outflows may delay the natural cooling of the Kootenai River downstream of the dam. The higher outflows in November and December are caused by the *December Libby Target Elevation* measure which, in MO3, calls for a reservoir elevation of 2,400 feet NGVD29 at the end of the December. This deeper draft to 2,400 feet NGVD29 at the end of December and the subsequent reservoir levels through the winter, however, may allow for the reservoir to warm earlier in the spring, providing for earlier (and beneficial) warming to water temperatures downstream of the dam.

There would be no changes to operations expected at Albeni Falls Dam so the temperature conditions in Lake Pend Oreille and the Pend Oreille River are expected to remain unchanged under MO3 and reflect conditions as described in the No Action Alternative.

***Total Dissolved Gas***

MO3 would modify Libby Dam's draft and refill operations resulting in a small increase in spill compared to the No Action Alternative. For the 80-year period from 1928 to 2008, model results predict 5 years when spill would occur under MO3 versus only 2 years when spill would occur for the No Action Alternative. Of those years with spill, there would be 27 days with TDG exceeding 110 percent for MO3 versus 8 days of spill exceeding the 110 percent TDG standard under the No Action Alternative. Regardless, Libby Dam is not expected to spill frequently under MO3, so downstream TDG saturations should remain less than 110 percent the majority of time.

Winter and spring Hungry Horse Dam operations are not specifically targeted by any measures, but due to changes in pool elevations at the end of September from the *Hungry Horse Additional Water Supply* measure and the *Sliding Scale at Libby and Hungry Horse* measure, winter and spring reservoir elevations and outflows would be impacted. Specifically, outflows from October through June would be lower under MO3 than the No Action Alternative. TDG below the dam under MO3 is expected to be relatively similar to the No Action Alternative in most years. The only exception would be for those years that follow a very dry year in which Hungry Horse Reservoir would not reach its normal end-of-September elevation; TDG in these years could be slightly reduced due to reduced outflow and spill (Appendix D).

Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills most years. Because there are little to no changes in Albeni Falls Dam operations between MO3 and the No Action Alternative, TDG levels under MO3 are expected to remain unchanged.

#### *Other Physical, Chemical, and Biological Processes*

The modified operations under MO3 would result in changes in the drafting depth, water elevations and retention times of Lake Koocanusa and Hungry Horse Reservoir. This could lead to higher flushing rates and moderate to major reductions in primary and secondary productivity in the reservoirs. Water quality chemical and biological parameters of concern in Lake Koocanusa that may be impacted by the MO3's shorter water residence times include nutrients such as phosphorus and nitrogen, suspended sediments, metals such as selenium, and phytoplankton.

Water quality conditions of Lake Pend Oreille and the Pend Oreille River described for the affected environment and the No Action Alternative are expected to continue under MO3.

### Sediment Quality

The operational measures related to spill control and timing, fish ladder configuration, spillway configuration, and other changes would not impact sediment movement and would not change existing sediment conditions in the Columbia River in Region A. Proposed changes to the timing and magnitude of operational flows also are not expected to impact sediment movement or existing sediment conditions; the proposed flows would be within the historical range of flows. No changes to sediment quality and current sedimentation patterns in Region A from MO3 are expected.

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

### Water Quality

#### *Water Temperature*

MO3 water temperatures are nearly identical to conditions under the No Action Alternative in Lake Roosevelt and the Columbia River downstream of Grand Coulee Dam, with few exceptions. Many of the MO3 measures (the *Planned Draft Rate at Grand Coulee* measure, the *Update System FRM Calculation measure, Lake Roosevelt Additional Water Supply,* and changes to inflow due to changes to upstream projects) would impact winter and spring storage and outflow; however, the measures are not expected to impact temperatures significantly. Spring/early summer water temperatures downstream of Grand Coulee Dam would increase slightly (on average, 0.3 degree Fahrenheit for the period of May through July) in the driest of years. Overall, negligible water temperature effects below Grand Coulee Dam are expected under MO3.

Changes to Grand Coulee Dam outflows would carry downstream through Rufus Woods Lake and Chief Joseph Dam. Modeled temperatures under MO3 Alternative at Chief Joseph Dam tailwater are similar to, or slightly cooler, than the No Action Alternative with the majority of temperature differences in the ±0.5 to 2 degrees Fahrenheit range. Tailwater temperatures under MO3 are predicted to exceed the Washington State standard of 63.5°F (17.5°C) as measured by the 7-day average of the daily maximum temperature in August and September, similar to No Action Alternative. Water temperature changes downstream of Grand Coulee and Chief Joseph dams are negligible under MO3.

#### ***Total Dissolved Gas***

Downstream of Grand Coulee Dam, major reductions in overall TDG would occur in the spring/early summer due to the *Update System FRM Calculation* and *Lake Roosevelt Additional Water Supply* measures. The operational measure *Grand Coulee Maintenance Operations* reduces the hydraulic capacity through the power plants, and if examined independently, would increase occurrence and magnitude of spill. This measure, however, is largely offset in the spring and early summer by other measures (including effects to inflows from changes in upstream dam operations combined with the Lake Roosevelt Additional Water measure). Additionally, the *Contingency Reserves During Fish Passage Spill* measure would allow reserves to be carried as part of juvenile fish passage spill in the lower Snake and Columbia River projects, potentially allowing Grand Coulee to generate more and hold less units in reserve, thus reducing TDG.

At Chief Joseph Dam, the MO3 forebay TDG saturations are predicted to be similar to the No Action Alternative under a wide range of flow and air temperature conditions. The number of days the tailwater exceeds the 110 percent TDG criteria is predicted to be similar to or slightly lower under MO3 depending on flow and meteorological conditions (Appendix D). TDG effects downstream of Chief Joseph Dam under MO3 are negligible as compared to the No Action Alternative.

#### ***Other Physical, Chemical, and Biological Processes***

Qualitative analysis suggests that, when compared to the No Action Alternative, MO3 could have some slight effects to physical, chemical, and biological processes in Lake Roosevelt. No effects would be likely to occur in the Columbia River immediately below Grand Coulee. Operational measures, including the *Update System FRM Calculations and Planned Draft Rate at Grand Coulee*, would result in a deeper winter draft in some years as early as January. In February and March, the reservoir would likely be drafted more slowly (from the *Planned Draft Rate at Grand Coulee* measure), which could reduce local landslides associated with high turbidity, and thereby improve water quality. Earlier and potentially deeper drafts in some years would not change the number of occurrences of repeated inundation and exposure of sediment in comparison to the No Action Alternative but may result in earlier and longer exposure of sediments. However, earlier and deeper reservoir drawdowns at Grand Coulee could result in the longer duration and exposure of reservoir shoreline sediment and increase the potential for mercury solubility in the reservoir water (although the measures would not change the number of occurrences of repeated inundation and exposure of sediment in comparison to the No Action Alternative). Increased exposure has the potential to increase mercury methylation rates, which could lead to greater buildup of mercury quantities in aquatic organisms (i.e., bioaccumulation) (Willacker 2016), among other potential contributing factors.

Chief Joseph Dam and Rufus Woods Lake elevations and flows under MO3 measures are predicted to be similar to the No Action Alternative. As such, the water quality of Rufus Woods Lake under MO3 would be similar to the No Action Alternative. The harmful algae blooms described for the affected environment and the No Action Alternative would be expected to continue in the future under MO3.

**Sediment Quality**

Similar to those described for Region A, sediment movement and existing sediment conditions would remain the same in Region B under MO3 in comparison to the No Action Alternative.

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

**Water Quality**

***Water Temperature***

Water temperature conditions at Dworshak Dam would be very similar under MO3 as compared to the No Action Alternative. Project operations would not change, and outflow temperatures would remain less than 54°F year-round.

Breaching the lower Snake River dams under MO3 would produce a major change in the volume and the amount of heat stored (i.e., heat storage capacity) in the lower Snake River. Water temperatures would respond accordingly, shifting from a reservoir to river system, with rapid warming in the spring and cooling in the fall. Based on modeling results, average August temperatures would be 0.2 degree Fahrenheit less at Lower Granite Dam and 1.8 degrees Fahrenheit cooler at Ice Harbor Dam, as compared to the No Action Alternative (Appendix D). Water temperature differences between impounded (No Action Alternative) and non-impounded river conditions (MO3) would be most notable in the fall and reach largest differences in November when there would be an average reduction in water temperatures of 3.6 degrees Fahrenheit at Lower Granite Dam and an 8.8 degree Fahrenheit decrease at Ice Harbor Dam. Maximum summer water temperatures would range from 72°F at Lower Granite Dam to 76°F at Ice Harbor Dam. The frequency of days when temperatures exceed 68°F would be highest in July and August and occur up to 45 percent of the time at Lower Granite Dam and 100 percent of the time at Ice Harbor Dam during these two months. Summer day/night temperature differences that range from 0.5 to 1.0 degree Fahrenheit under the No Action Alternative would increase to 2.5 to 3.5 degree Fahrenheit, providing nighttime cooling.

***Total Dissolved Gas***

TDG downstream of Dworshak Dam would be very similar under MO3 when compared to the No Action Alternative; effects are negligible compared to the No Action Alternative.

TDG above 120 percent could occur at the Lower Snake River dams during the spring prior to breaching since only three powerhouse units would be available to pass river flow. Remaining flow would go over the spillways, and the amount of TDG produced would depend on the spring inflows, but it could exceed 130 percent.

After breaching the dams, there would be no spill and consequently no resulting TDG at the lower Snake River dams. Plunge pools that could form during development of a stable channel morphology under the new flow regimen could also produce localized TDG greater than 110 percent for short periods of time.

***Other Physical, Chemical, and Biological Processes***

The physicochemical and biological processes in Dworshak Reservoir and downstream of the project would not differ from the No Action Alternative if MO3 is implemented.

Changes would occur to several of the physical and chemical constituents in the lower Snake River during breaching. Effects would be largest during reservoir drawdown and immediately following breaching. Suspended solid concentrations are expected to peak to more than 24,000 mg/L during the first breach (Lower Granite and Little Goose) and 16,000 mg/L during the second breach (Lower Monumental and Ice Harbor). Concentrations greater than 5,000 mg/L would last for 26 and 18 days during the first and second dam breaching events, respectively (Section 3.3, River Mechanics). Because the sediments and the interstitial waters (water between the sediment particles) are deprived of oxygen in the reservoir, they would create an oxygen demand when the oxygen-deprived water and sediment enter the water column during breaching, resulting in very low oxygen and even anoxic (no oxygen) conditions during reservoir drawdown and breach (Annex C). Water column concentrations of nitrogen and phosphorus would also increase as interstitial water is mixed with the river water during breaching, with total ammonia-nitrogen (a gaseous combination of hydrogen and nitrogen) the primary constituent of concern. Ammonia concentrations could exceed the EPA's aquatic life ambient water quality criteria for chronic toxicity as sediment is mixed with river water. Average ammonia elutriate concentrations for the four lower Snake River reservoirs in 1997 (Corps 2002) ranged from 2.5 to 3.6 mg/L, with some individual values exceeding 12 mg/L. Although actual water column concentrations would differ from elutriate concentrations, this data suggests that there is a potential for ammonia toxicity under MO3. A more concise estimate of the magnitude, duration, and frequency of possible in-water ammonia concentrations and resulting toxicity to fish would require additional sediment characterization coupled with fate/transport modeling. Oxygen and nutrient concentrations would normalize as suspended solids decrease to No Action Alternative levels. Intermittent oxygen deficits and nutrient pulses could occur for years after breaching, depending on the hydrologic and biotic processes at the time, and as material from exposed mudflats moves into the river due to slumping or runoff. However, there is uncertainty regarding these longer term (>2 year) effects.

Primary productivity would change from a system based on phytoplankton to attached benthic algae. During, and for some time after breaching, phytoplankton productivity would decrease as a result of increased suspended solids concentrations and reduced light transparency.

Current attached benthic algae communities would be exposed to air and desiccate. The transition phase to return the substrate to sand, cobble, and gravel could take years depending on runoff, location, and precipitation. After a new equilibrium of sediments is established, primary production would be expected to be higher per length of river than it was during impoundment under the No Action Alternative.

Secondary production would also change in the lower Snake River if MO3 were implemented. Zooplankton would become minor components of the food web, and aquatic insect larvae would become the main secondary producers.

**Sediment Quality**

MO3 would include breaching the four lower Snake River dams. This alternative would have a major impact on sediment processes within the Snake River. The dam breaching process would release a large volume of currently shoaled (buildup of sediment into shallow areas) sediment. The release of this sediment would cause both short-term effects (loss of dissolved oxygen, very high suspended solids, smothering of downstream aquatic organisms) and longer-term effects (changes to bioaccumulation of pollutants in aquatic organisms, long-term changes to bank erosion and groundwater discharges, changes to shoaling patterns within the lower Snake River). However, it should be noted that the sediment study did not include existing bridges and therefore does not consider bridge-related scour and deposition potential. Overall, the sediment in the lower Snake River would move downstream during and after the dam breach. The release of the currently shoaled sediment, which contains historical pollutants (pesticides, dioxins, other human-sourced pollutants and naturally occurring mercury in volcanic soils and from atmospheric deposition) would impact sediment quality in the lower Snake River (Appendix D). Future sediment accumulations in the lower Snake River would be limited to backwater areas and would largely accumulate downstream in the Region D (as discussed below). See Section 3.3, River Mechanics, for additional discussion of sediment movement.

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

**Water Quality**

***Water Temperature***

Under MO3 and as with the No Action Alternative, the four lower Columbia River reservoirs (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no stratification during the summer months, largely due to the time water is in the reservoirs and water mixing. In contrast with the No Action Alternative, day-to-night and day-to-day variability may be greater in the lower Columbia River under MO3, though it would be far less pronounced than that anticipated in the lower Snake River (Region C). Maximum tailwater water temperatures and the frequency of water temperature standard exceedances would be similar for MO3 and the No Action Alternative, with minor effects expected at McNary, John Day, and The Dalles Dams and negligible effects expected at Bonneville Dam (Appendix D).

#### *Total Dissolved Gas*

Under MO3, the *Spring Spill to 120 percent TDG* measure calls for managing juvenile fish passage spill to not exceed a 120 percent TDG saturation at the tailrace of all four lower Columbia River dams from April 10 to June 15; there would be no TDG limit in the forebays under this alternative, resulting in larger amounts of spill at times. Additionally, the *Reduced Summer Spill* measure aims to reduce the duration of summer juvenile fish passage spill at the lower Columbia River dams, ending summer spill on July 31. As a result, MO3 model results show, as compared to the No Action Alternative, similar or higher tailwater TDG saturations April through June and lower TDG saturations in August. At most dams and under most river and weather conditions, forebay TDG saturations would be similar or lower under MO3 as compared to the No Action Alternative, especially in the McNary forebay because it would no longer be receiving elevated TDG from the lower Snake River projects. In general, TDG effects under MO3 would be minor to negligible in the lower Columbia River.

#### *Other Physical, Chemical, and Biological Processes*

Breaching of the lower Snake River dams would result in sediment being transported downstream to the McNary Reservoir, particularly in the years immediately following breaching (near-term). As a result, short-term major negative effects associated with the sediment transport would be expected in the McNary Reservoir (Appendix D). Dissolved oxygen, light attenuation, phytoplankton, zooplankton, and productivity would likely be depressed, while total suspended solids, turbidity, nutrients, organics, and metals would likely increase. Near-term transport of silt- and clay-sized particles downstream of McNary Dam may cause similar effects to the downstream reservoirs, though the effects would likely be much less severe than in the McNary Reservoir because the majority of coarse sediment is expected to be trapped by McNary Dam. The near-term increases in suspended sediment and turbidity (and associated effects) would eventually level off, and more typical seasonal fluctuations would occur long term in the McNary Reservoir and further downstream (Section 3.3, River Mechanics). Long-term increases in the estimated volumes of silt- and clay-sized particles transported to and downstream of the McNary Reservoir, as compared to the No Action Alternative, create the potential for increases in total nutrients, metals, and organic concentrations as these constituents are often associated with finer sediment particles. The magnitude of these long-term effects would reflect inflows after the system equilibrates as well as watershed land use practices and runoff events. The sediment shoaled behind the lower Snake River and McNary Dams has not been sampled in over 20 years, and there is uncertainty in the chemical characteristics of the sediment.

### Sediment Quality

With the exception of the area upstream of and in the McNary Reservoir, there would be no impact to sediment movement or condition in the lower Columbia River in Region D. Sediment movement and existing sediment conditions would remain the same at John Day, The Dalles, and Bonneville Dams in Region D under MO3. As discussed for Region C above, the sediment in the lower Snake River would move downstream during and after the dam breach. The release of the sediment, which contains historical pollutants (pesticides, dioxins, other human-sourced pollutants and naturally occurring mercury in volcanic soils and from atmospheric deposition) would impact sediment quality in the McNary Reservoir. In the future, the majority of the sediment moving through the lower Snake River would accumulate within the McNary Reservoir with a smaller amount of fine-grained suspended material passing through the dam, along the lower Columbia River, and out into the estuary. Future sediment accumulation at the lower Columbia River dams would not be greatly impacted. See Section 3.3, *River Mechanics*, for additional discussion of sediment movement.

**SUMMARY OF EFFECTS**

Although the effects of MO3 differ across the various projects in terms of water quality, they can generally be categorized as follows:

In Region A, MO3 would result in water temperatures that would be similar to the No Action Alternative. TDG levels would be similar to the No Action Alternative, though there may be a slight reduction in spill and associated TDG at Hungry Horse Dam during very dry years. There may be a decrease in primary and secondary productivity in the reservoirs.  Overall, MO3 would have a minor effect on water quality in Region A.

In Region B, MO3 water temperatures would be nearly identical to conditions under the No Action Alternative, with few exceptions. Downstream of Grand Coulee Dam, major reductions in overall TDG may occur in the spring/early summer. The Chief Joseph Dam forebay TDG saturations are predicted to be similar to the No Action Alternative under a wide range of flow and air temperature conditions. Mercury mobilization may occur slightly more frequently in Lake Roosevelt; no other water quality impairments are anticipated.

Region C would have the largest change in water quality under MO3. Breaching the lower Snake River dams under MO3 would produce a major change in the volume and the amount of heat stored in the lower Snake River. Water temperature differences (up to 8.8 degrees Fahrenheit) between impounded (No Action Alternative) and non-impounded (MO3) river conditions would be greatest in the fall.  TDG downstream of Dworshak Dam would be very similar under MO3. Due to the breaching, there would be no spill and consequently no resulting TDG at the lower Snake River dams. However, some elevated TDG would occur during preparation and implementation of dam breaching. Dam breaching would result in elevated suspended solids, particularly during and immediately following breaching, which could temporarily result in low oxygen conditions and elevated ammonia concentrations. Primary and secondary productivity would also temporarily decrease due to the suspended solids. In the long term, primary and secondary productivity is anticipated to be greater compared to the No Action Alternative. The release of sediment during and following the dam breach would also cause both short-term effects (loss of dissolved oxygen, very high suspended solids, smothering of downstream aquatic organisms) and longer-term effects (changes to bioaccumulation of pollutants in aquatic organisms, long-term changes to bank erosion and groundwater discharges, changes to shoaling patterns within the lower Snake River). Overall, MO3 would have a major short-term negative impact on water quality due to the mobilization of sediment during dam breaching.

Over the long term, MO3 would have moderate to major beneficial effects on water quality in Region C through the restoration of natural, river, and water quality processes; a substantial cooling effect in the fall; greater nighttime cooling and respite from warm water temperature conditions in the summer; and a reduction in overall system TDG.

In Region D, day-to-night and day-to-day water temperature fluctuations may be greater under MO3, but the maximum and frequency of water temperatures exceeding state water quality standards would largely remain the same as the No Action Alternative. Region D would have similar, though lesser effects as Region C from the dam breaching. TDG levels would be similar under MO3, though McNary Reservoir would no longer be receiving elevated TDG from the lower Snake River projects. Sediment and contaminants being transported to McNary Reservoir during and following the dam breach would result in reduced dissolved oxygen, light attenuation, phytoplankton, zooplankton, and productivity; while total suspended solids, turbidity, nutrients, organics, and metals would increase in the short term. Overall, MO3 would have a moderate short-term negative impact on water quality, particularly in McNary Reservoir due to the mobilization of sediment during dam breaching. Over the long term, MO3 would have a negligible to minor beneficial effect on water quality in Region D.

For further details, please refer to the Water Quality Technical Appendix D.

### *3.4.3.7 Multiple Objective Alternative 4*

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

**Water Quality**

***Water Temperature***

Under MO4, the selective withdrawal systems at Hungry Horse and Libby Dams would continue to be operational and therefore continue to maintain water temperatures at both projects in manners similar as those described in the No Action Alternative. Changes in water temperatures downstream of Libby Dam could occur due to the *December Libby Target Elevation* and *Modified Draft at Libby* measures. With these measures, water temperatures downstream of Libby Dam could be warmer in the winter and colder in the early spring as compared to the No Action Alternative.

There would be no changes to operations expected at Albeni Falls Dam for median and high water years under MO4, so the temperature conditions in Lake Pend Oreille and the Pend Oreille River are expected to remain unchanged and reflect conditions as described in the No Action Alternative for the median and high flow conditions. For the drier 40 percent of years, Lake Pend Oreille would be up to 2.6 feet lower in the summer due to higher outflows from Albeni Falls Dam. Due to this change, it is possible that higher summer flows might increase or decrease the temperature (ranging from 0.9 to 1.8 degrees Fahrenheit) in the Pend Oreille River depending on flow and weather conditions (Appendix D).

### *Total Dissolved Gas*

TDG below Hungry Horse Dam in the South Fork Flathead River could be affected by multiple operational measures. All of these measures may result in a deeper drawdown of the reservoir; however, these reductions would likely occur after the part of the year when spill and associated high TDG generally occur. TDG may be reduced in dry years subsequent to a large drawdown in the reservoir under MO4 because the reservoir would enter into the second year with much less carryover, which could, in turn, result in lower spill from the dam in the early months of the year. Despite the potential to reduce TDG in these water years, the TDG below the dam under MO4 is expected to be similar to the No Action Alternative for most conditions.

MO4 would modify Libby Dam's draft and refill operations, resulting in a small increase in spill compared to the No Action Alternative. For the 80-year period from 1928 to 2008, model results predict 6 years with spill under MO4 versus only 2 years for the No Action Alternative. Of these years when spill would occur, 43 days would have TDG exceeding 110 percent for MO4 versus only 8 days exceeding 110 percent TDG for the No Action Alternative. Regardless, Libby Dam is not expected to spill frequently under MO4, so downstream TDG saturations should remain less than 110 percent the majority of time.

Albeni Falls Dam spill is highly dependent on runoff volumes. Historically, Albeni Falls Dam spills most years. Because there are few changes in Albeni Falls Dam operations between MO4 and the No Action Alternative, spillway operations and TDG conditions under MO4 are expected to be similar to the No Action Alternative.

### *Other Physical, Chemical, and Biological Processes*

The modified operations under MO4 could result in changes in the drafting depth, water elevations, and retention times of Lake Koocanusa. Changes in reservoir elevation and retention times may result in changes to concentrations of nutrients such as phosphorus and nitrogen, metals such as selenium, and phytoplankton. This may lead to greater quantities of selenium and nitrate in Lake Koocanusa and the Kootenai River downstream of Libby Dam. The shorter residence time (amount of time that water stays in the reservoir) may also allow phosphorus to move farther down reservoir before settling out or transforming. This increase in nutrients available in the reservoir could make the lake more susceptible to increased phytoplankton blooms, including potentially toxic species, under MO4.

The decrease in pool elevation and volume during the summer months anticipated under MO4 at Hungry Horse and Libby Reservoirs may result in reduced biological productivity, which could impact phytoplankton and zooplankton populations that are important food sources for fish. In addition, the increased outflow under MO4 from both Hungry Horse and Libby Dams could reduce downstream river productivity with increasing flow from conditions in the No Action Alternative.

Water quality conditions in Lake Pend Oreille and the Pend Oreille River would be very similar under MO4 when compared to the No Action Alternative. However, for the drier 40 percent of years when the lake would be 2.6 feet lower in the summer, the shallow nearshore areas may be more susceptible to increases in macrophyte and periphyton growth and coverage. In addition, if there are increases in nearshore nutrients, it is possible that nuisance aquatic growths may further impair beneficial uses under MO4.

**Sediment Quality**

Many of the proposed actions under MO4 are related to juvenile fish passage. These actions (changes to fish ladders, screens, intakes, bypass areas) would not impact sediment movement and would not change existing sediment conditions in Region A. Proposed changes to the timing and magnitude of operational flows also are not expected to impact sediment movement or existing sediment conditions; the proposed flows are within the historical range of flows.

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

**Water Quality**

***Water Temperature***

From January through March, more empty space is held in Lake Roosevelt under MO4 for the updated winter space requirements for rain-induced flood mitigation (*Winter System FRM Space*), as well as the decreased draft rate used in planning the drawdown (*Planned Draft Rate at Grand Coulee*). Water temperatures in Lake Roosevelt and downstream of the dam are not anticipated to change from the No Action Alternative in average and wet water years; however, in drier years, comparison between MO4 and the No Action Alternative indicates that water temperatures may increase early in the year below the dam. Similar to the No Action Alternative, Lake Roosevelt would refill in July in average to wet years; however, in drier years, when Grand Coulee is managed to support the *McNary Flow Target* measure, the reservoir would not refill. Rather than being stored, warm water would be passed through the reservoir in May through July, creating conditions that are 0.8 degrees Fahrenheit warmer, on average, downstream of Grand Coulee Dam. Late summer temperatures would tend to be slightly (1 to 2 degrees Fahrenheit) warmer, except in the driest/warmest scenario, when model results show a decrease in temperature. The cause of this impact is likely a combination of changes in storage timing and outflows and over-simplifying model assumptions. In most years, there tends to be a rise in water temperature in September under MO4, which coincides with a reduction in total project outflows that are lower under MO4 as compared to the No Action Alternative. Water quality standards below Grand Coulee are expected to continue to be exceeded in August and September, as compared to the No Action Alternative. Overall water temperature effects downstream of Grand Coulee Dam are expected to be minor.

Flow pattern changes in Grand Coulee Dam outflows would be seen through Rufus Woods Lake and Chief Joseph Dam, as well as at the tailwater and downstream, under MO4. MO4 water temperatures at Chief Joseph Dam tailwater are similar to, or slightly warmer, than the No Action Alternative with the majority of temperature differences in the 1 degree Fahrenheit range. Tailwater temperatures under MO4 are predicted to exceed the Washington State standard of 63.5°F) as measured by the 7-day average of the daily maximum temperature in August and September; this would occur under the No Action Alternative as well. Water temperature effects downstream of Chief Joseph Dam are minor based on the logic presented in Section 3.4.3.2.

***Total Dissolved Gas***

There are multiple measures (*Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, *Winter System FRM Space*, *Lake Roosevelt Additional Water Supply*, *Grand Coulee Maintenance Operations*, *McNary Flow Target*) under MO4 that would result in changed operations at Grand Coulee Dam.

These operational measures are also included in MO1 with one exception—the addition of the *McNary Flow Target* measure. During drier years, the *McNary Flow Target* measure would require the release of up to an additional 2 MAF of water from Lake Roosevelt to help maintain fish flow objectives in the lower river; 1.0 MAF of that volume is backfilled from Libby, Hungry Horse, and Albeni Falls Dams during summer. While this would result in changes to outflows, this measure would not result in increases in TDG from the No Action Alternative at Grand Coulee Dam as the measure would be implemented in below average flow years, and in actual operations, spill would be avoided to implement this measure.

The *Winter System FRM Space* measure could result in a deeper draft and larger outflow in the month of December; however, the difference in TDG response between MO4 and the No Action Alternative would be similar in this time of year. From January through March, because the reservoir is lower for the FRM measures, there would typically be lower outflows, and in some situations, less spill (and corresponding TDG) in those following few months (mid-April to mid-June). The *Grand Coulee Maintenance Operations* measure has the potential to increase spill through the reduction in the hydraulic capacity of the powerhouse at Grand Coulee; however, the other actions under MO4 tend to minimize the effects of these measures on TDG and the higher TDG that would be associated with this measure is not reflected in modeled results. Overall, MO4 results in major reductions in TDG downstream of Grand Coulee Dam as compared to the No Action Alternative.

At Chief Joseph Dam, forebay TDG saturations are predicted to be similar under MO4 as compared to the No Action Alternative under a wide range of flow and air temperature conditions. The number of days the tailwater exceeds the 110 percent TDG criteria is predicted to be slightly lower under MO4 than the No Action Alternative for all flow and meteorological conditions; TDG effects below Chief Joseph Dam are considered negligible under MO4.

***Other Physical, Chemical, and Biological Processes***

Overall, MO4 operational measures would result in an earlier winter drawdown of Lake Roosevelt and a larger drawdown in the spring; however, the overall lake level is expected to be similar to the No Action Alternative lake elevation by July 1. River mechanics analysis indicates minor increases in the mobility of bed material in Lake Roosevelt under MO4. If contaminated slag is present in the mobilized bed material, this could create additional toxicity in fish and other aquatic organisms. However, the change in potential toxicity is unknown. Reservoir drawdowns of longer duration under MO4 increase the exposure of shorelines. Increased exposure has the potential to increase mercury methylation rates, which could lead to greater buildup of mercury quantities in aquatic organisms (i.e., bioaccumulation) (Willacker 2016).

Decreased residence time, associated with higher outflows and reduced residence times when the *McNary Flow Target* measure is implemented, within the lake could beneficially affect some areas that are intermittently impaired by algae blooms, such as the section of reservoir where the Spokane River enters into the reservoir; lower DO in this reach of reservoir was also slightly improved in low-flow years. The lower drawdown rate associated with operational measure *Planned Draft Rate at Grand Coulee* could reduce turbidity in the lake due to shoreline erosion.

Chief Joseph Dam and Rufus Woods Lake elevations and flows under MO4 are predicted to be similar to the No Action Alternative. As such, the water quality of Rufus Woods Lake under MO4 would be similar to the No Action Alternative. The harmful algae blooms described for the affected environment and the No Action Alternative would be expected to continue in the future under MO4.

**Sediment Quality**

MO4 operational and structural measures would not impact sediment movement and would not change existing sediment conditions in Region B. Operational flows under MO4 would be within the historical range of flows; therefore, sediment conditions are not expected to change.

## REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

### Water Quality

#### *Water Temperature*

Water temperature conditions at Dworshak Dam would be very similar under MO4 as the No Action Alternative. Short-term differences could occur, but the outflow temperatures would remain less than 54°F year-round, and reservoir temperatures would not change.

Temperatures at the four lower Snake River projects would be the same under MO4 as the No Action Alternative, suggesting that water temperatures are not sensitive to the change in spill from the No Action Alternative in MO4 for the lower Snake River.

#### *Total Dissolved Gas*

TDG downstream of Dworshak Dam would be very similar under MO4 when compared to the No Action Alternative. The primary difference would be some reduction between April and

June, when water is typically released from the dam for flood risk management and refill purposes.

The *Spill to 125 percent TDG* measure sets juvenile fish passage spill to not exceed 125 percent TDG saturation, as measured at the tailrace, at all lower Snake River dams from March 1 to August 31; there is no forebay criteria. Due to the earlier start of juvenile fish passage spill and the higher tailwater TDG limits, MO4 model results show moderate to major increases in forebay and tailwater TDG saturations as compared to the No Action Alternative. It should be noted that there are instances in which TDG does not hit the 125 percent limit. This is primarily due to the assumptions used to determine spill at the onset of modeling. In real-time, the 125 percent TDG limits could likely be met more often, as long as there was enough water to spill while maintaining minimum generation at the projects.

***Other Physical, Chemical, and Biological Processes***

For the projects in Region C, MO4 is not expected to alter other physical, chemical and biological water quality parameters as compared to the No Action Alternative.

**Sediment Quality**

No changes to sediment quality and current sedimentation patterns in the Region C are expected as compared to the No Action Alternative.

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

**Water Quality**

***Water Temperature***

Under MO4 and as with the No Action Alternative, the four lower Columbia River reservoirs (McNary, John Day, The Dalles, and Bonneville) would continue to show weak to no stratification during the summer months, largely due to the short residence time, wind and flow-induced turbulent diffusion, and convective mixing that occurs in the reservoirs. Maximum tailwater water temperatures and the frequency of water temperature standard exceedances would be similar for MO4 and the No Action Alternative over a range of river and weather conditions. Minor effects to water temperature are anticipated downstream of McNary Dam, while negligible effects are expected downstream of John Day, The Dalles, and Bonneville Dams.

***Total Dissolved Gas***

The *Spill to 125 percent TDG* measure sets juvenile fish passage spill to not exceed 125 percent TDG saturation, as measured at the tailrace, at all lower Columbia River dams from March 1 to August 31; there is no forebay criteria. Due to the earlier start of juvenile fish passage spill and the higher tailwater TDG limits, there would be negligible to major increases in forebay and tailwater TDG saturations as compared to the No Action Alternative, depending on the project.

It should be noted that there are instances in which TDG does not hit the 125 percent limit. This is primarily due to the assumptions used to determine spill at the onset of modeling. In real-time, the 125 percent TDG limits could likely be met more often, as long as there was enough water to spill while maintaining minimum generation at the projects.

***Other Physical, Chemical, and Biological Processes***

For the lower Columbia River projects in Region D, MO4 is not expected to alter other physicochemical and biological water quality parameters as compared to the No Action Alternative.

**Sediment Quality**

No changes to sediment quality and current sedimentation patterns in the Region D are expected as compared to the No Action Alternative.

**SUMMARY OF EFFECTS**

Although the effects of MO4 differ across the various projects in terms of water quality, they can generally be categorized as follows.

In Region A, with the exception of Lake Pend Oreille, MO4 water temperatures would largely be similar to the No Action Alternative. In the Pend Oreille River, during dry years, there would be a change in water temperatures ranging from a decrease of about 0.9 degree Fahrenheit to an increase of 1.8 degrees Fahrenheit in the summer, depending on flows and weather. The TDG below the dams under MO4 are expected to be similar to the No Action Alternative for most conditions. Minor changes to the physical, chemical, or biological processes in the reservoirs located in Region A would occur. MO4 would not impact turbidity or sediment concentrations in the region. Overall, water quality effects in Region A are expected to be negligible to minor.

In Region B, minor water temperature effects between MO4 and the No Action Alternative would be expected. Major reductions in TDG are expected below Grand Coulee Dam while negligible effects are expected downstream of Chief Joseph Dam. MO4 operational measures would result in an earlier winter drawdown of Lake Roosevelt and a larger drawdown in the spring. This could prolong sediment exposure in the top 10 to 20 feet of the reservoir and promote a higher rate of mercury cycling. Overall, however, water quality effects in Region B are expected to be negligible to minor as compared to the No Action Alternative.

In Region C, water temperatures would largely be the same as the No Action Alternative. TDG downstream of Dworshak Dam would be very similar under MO4 when compared to the No Action Alternative. Due to the earlier start of juvenile fish passage spill and the higher tailwater TDG limits, MO4 would have notable increases in forebay and tailwater TDG saturations as compared to the No Action Alternative. There would be no changes to other water quality parameters. With the exception of TDG, these effects would have a negligible impact to water quality. For TDG levels, there would be a moderate to major change as compared to the No Action Alternative.

In Region D, due to the earlier start of juvenile fish passage spill and the higher tailwater TDG limits under MO4, there would be notable increases in forebay and tailwater TDG saturations as compared to the No Action Alternative. There would be minor water temperature effects downstream of McNary Dam due to summer warming from the *McNary Flow Target* measure; effects further downstream at John Day, The Dalles, and Bonneville Dam would be negligible. TDG effects would vary by project with negligible to major changes expected as compared to the No Action Alternative.

For further details, please refer to the Water Quality Technical Appendix D.

### 3.4.4 Tribal Interests

Water quality concerns vary throughout the basin and include issues caused by operations of the 14 Federal projects (such as TDG) and issues caused by urban growth, agriculture, pollution, and industry (Section 3.4.2.1, Water Quality). Some tribes in the study area have water quality standards that have been approved by EPA. Contamination, be it through impaired water quality standards, heavy metals coming from upriver mining activities, radioactive sediments near Hanford, affects Native American people, tribes, and culture.

The water quality analysis (Section 3.4.3) described varying effects of the MOs across the different regions and projects. The analysis focused on operational effects to TDG, temperature, and other water quality conditions. MO1, MO2, and MO4 would have varying impacts on water quality, depending on location (MO3 is discussed below), primarily through TDG, temperatures, and nutrients (productivity). Of concern for tribal interests are measures at Grand Coulee. MO2 and MO3 would result in increased exposure of reservoir shoreline sediment and subsequent increased potential of mercury cycling which could lead to greater bioaccumulation, particularly between April and July due to the oxidization of metals in sediments along the exposed shorelines. This may lead to increased fish consumption advisories for Lake Roosevelt, which would further adversely affect tribes. Water quality effects may also harm tribal net pen fisheries. MO2 and MO4 may also impact dissolved oxygen levels near the Spokane Arm, and water quality concerns there are of concern to the Spokane Tribe of Indians. MOs are not expected to affect sediments near Hanford.

MO3 would result in impaired water quality in the lower Snake River reach (Region C) due to dam breaching for 2 to 10 years. As described in Section 3.4.3, there would be short-term and longer-term effects to water quality down to McNary Reservoir and below. There would be changes in temperature, TDG, and sediments and an increase in total nutrient, metal, and organic concentrations associated with finer sediment particles. While there would be significant short-term effects to water quality from dam breaching, the undammed river through this reach presents a natural flow regime which may be culturally important to tribes. Many tribes expressed a desire to have the Snake River return to more normative flow conditions. For them, dam breaching would be culturally meaningful.

Many tribes in the basin have voiced concerns over water quality in the Columbia River. Studies have shown that tribal people in the Pacific Northwest consume more fish than non-tribal residents (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 consequently, they question whether the national fish consumption rate of 12 ounces per week for adults used by the United States Food & Drug Administration and Environmental Protection Agency (2015-2020 Dietary Guidelines for Americans, https://health.gov/dietaryguidelines/2015/guidelines/) is applicable to tribal members. Furthermore, existing health advisories for fish caught in some stretches of the river reduce the recommended consumption level considerably:

> "The Washington Department of Health (DOH) has issued this fish consumption advisory for Lake Roosevelt due to mercury contamination: pregnant women, women of childbearing age, and children under six years of age should eat no more than two meals of walleye (8-ounce portion) a month" (https://wdfw.wa.gov/fishing/locations/lowland-lakes/franklin-roosevelt-lake).

In their Tribal Perspective submittal, the Confederated Tribes of the Colville Reservation captured this concern by discussing concerns among its elders:

> "Knowing smelter contamination from industrial activities in Trail, B.C. pollutes the Columbia River; she is hesitant to continue the ways taught to her. She still sweats intermittently, but fears that by heating the rocks, vaporizing the water, and burning fir boughs, toxins will be released and she or her family will inhale or ingest them., and that a human health risk might exist among tribal members from exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin) and other waterborne toxic contaminants" (See Appendix P).

Although tribal members rely on fish as part of their daily diet to a greater degree than non-tribal people, their consumption rates are still a small fraction of their heritage consumption rates.  Many of the tribes referred to this in their Tribal Perspectives.  The Coeur d'Alene Tribe provided a study of their heritage fish consumption rates which asserts "Water quality is of great importance to the Coeur d'Alene Tribe." and then provides a number of academic studies which place heritage consumption rates for tribes of the Columbia basin in general in a range with a high end of 1,000 pounds of fish per year, per member of the tribe.  Today, estimates place annual consumption at 117 pounds per year, per member (Heritage Fish Consumption Rates of the Coeur d'Alene Tribes, RIDOLFI Inc. 2016).

Another tribe provided the following: “Shoshone and Bannock peoples consumed approximately 700 pounds of salmon per person annually, prior to the development of the System. At present, only 1.2 pounds of salmon are consumed per tribal member annually.” The Confederated Salish and Kootenai Tribes of the Flathead Reservation in their Tribal Perspective discuss the importance of fish to their tribal member’s cultural diet, to protect these resources, and try to return to heritage consumption rates:

> “have developed federally-approved water quality standards for the Flathead Indian Reservation. The CSKT are continuously working to protect and improve the water quality in Reservation waters, including Flathead Lake, by various means, including: membership in the Flathead Basin Commission; negotiating with trans-boundary interests regarding coal development in the North Fork Flathead River; participating in FERC-relicensing workgroups; implementing Sėliš Ksanka Ql̓ispė Hydroelectric Project (SKQ Dam, formerly Kerr Dam) environmental mitigation requirements; and operating of a certified Tribal water quality laboratory.” (See Appendix P).

## 3.5 AQUATIC HABITAT, AQUATIC INVERTEBRATES, AND FISH

### 3.5.1 Introduction

This section provides a description of the existing Affected Environment that aquatic species inhabit in the CRS. This section also evaluates the Environmental Consequences (i.e. effects) associated with the No Action Alternative, MO1, MO2, MO3, and MO4. Each alternative evaluated in this EIS balanced multiple objectives (described in Chapter 2) and therefore, resulted in different effects which are summarized separately. The analytical tools and methods used by the co-lead agencies to evaluate the environmental consequences of the alternatives are described in Section 3.5.3.1. This section focuses on the direct and indirect effects of the alternatives while Chapter 5 discusses additional mitigation and Chapter 6 outlines the cumulative effects with other actions.

The analysis of environmental consequences performed in this chapter is specific to the measures developed by the co-lead agencies in conjunction with the cooperating agencies. The individual measures contained in the multiple objectives do not necessarily reflect full consensus of the co-lead agencies and cooperating agencies, but were analyzed to consider a wide range of possible actions and associated consequences or effects (see Chapter 2).

This EIS assesses the impacts of operating and maintaining the CRS while also implementing actions that address the effects of CRS operations and maintenance and conserve fish and wildlife. The analysis in the environmental consequences section (3.5.3) focuses on evaluating the impacts of the EIS alternatives on aquatic species. The co-lead agencies evaluate these consequences on multiple categories of species including ESA-listed and non-ESA listed, as well as anadromous and resident species. The co-lead agencies also consider the impacts of the alternatives on the broader food availability for the affected species, such as impacts to macroinvertebrate communities.

In general, the distribution and abundance of species affected by the CRS are influenced by a variety of biotic and abiotic factors that interact with aquatic species at various life stages. The species described herein use a broad range of habitats depending on life stage, and can thus be more (or less) sensitive to natural and anthropogenic stressors, only some of which are caused by CRS operations and maintenance, depending on when and where those stressors overlap with the species' presence.

For context, it should also be noted that there are a host of other regional entities, in addition to the CRS co-lead agencies, who are formally engaged in mandated and voluntary actions to address a wide range of impacts to salmon and steelhead in and around the Columbia Basin and within areas impacted by the CRS. From 2010 to 2019, NMFS's West Coast Region has completed over 400 "formal" and "formal programmatic" biological opinions (BiOps) applicable to actions that impact ESA listed salmon and steelhead in the affected environment. While this list includes activities undertaken by the co-lead agencies, many of these BiOps address impacts that are upstream, downstream, or inland from CRS management and non-operational conservation measures. This also includes related mitigation activities, including non-CRS co-lead agency activities and impacts:

- Federal and non-federal hydroelectric dam operations and assets and related fish passage, turbine mortality, predation, migration timing, water levels, habitat blockage, and all related effects
- Water quality and related impacts of water temperature, total dissolved gas, withdrawals, storage, irrigation, siltation, pollution, farming, grazing, logging, mining, standards compliance and enforcement, dredging, berth deepening, and all related effects
- Habitat conservation and land management and related impacts of floodplain management, road and bridge projects, other construction near water ways, forestry practices, agricultural practices, marine docking and transportation, and all related effects
- Hatcheries and harvest management and related impacts of competition and interbreeding, commercial and recreational fish harvest, decadal or year-to-year changes in ocean environments, drought conditions, hatchery take for propagation, disease and toxics exposure and all related effects

The region's collective ability to successfully carry out actions that benefit salmon and steelhead is dependent on many common effects, in combination with the actions included in the analysis. It is also dependent on sustained compliance with regulatory requirements and building upon successful implementation efforts to date.

### 3.5.2 Affected Environment

The Columbia River Basin is home to a variety of aquatic organisms, including rare, threatened, and endangered aquatic species. This section begins with an introduction and background section, which includes general discussions of the overall study area (Figure 3-109) and a discussion of past effects. The affected environment includes a description of aquatic habitat elements, followed by a description of anadromous fish, resident fish, and aquatic macroinvertebrates that may be affected by the MOs. Existing conditions are described by species or region, with species-specific details where relevant to the analysis, including distribution, life history patterns, population status, and habitat requirements. Section 3.5.3, Environmental Consequences describes the effects of the various MOs on aquatic habitat, fish, and macroinvertebrates, as compared to the No Action Alternative.

#### *3.5.2.1 Analysis Area and Background*

The primary area of analysis of effects to fish and aquatic habitats includes the mainstem Columbia and Snake Rivers as well as the confluences of major tributaries. Potential effects in Canadian portions the mainstem Columbia, as well as the Kootenai and Pend Oreille rivers downstream of CRS projects were not considered in this analysis. The effects in this resource were generally expected to be similar to the effects described on those tributaries in the United

States. Other rivers in the study area are described where measurable changes in the abundance of salmon, steelhead, lamprey, and other key fish species have altered components of the ecosystem.

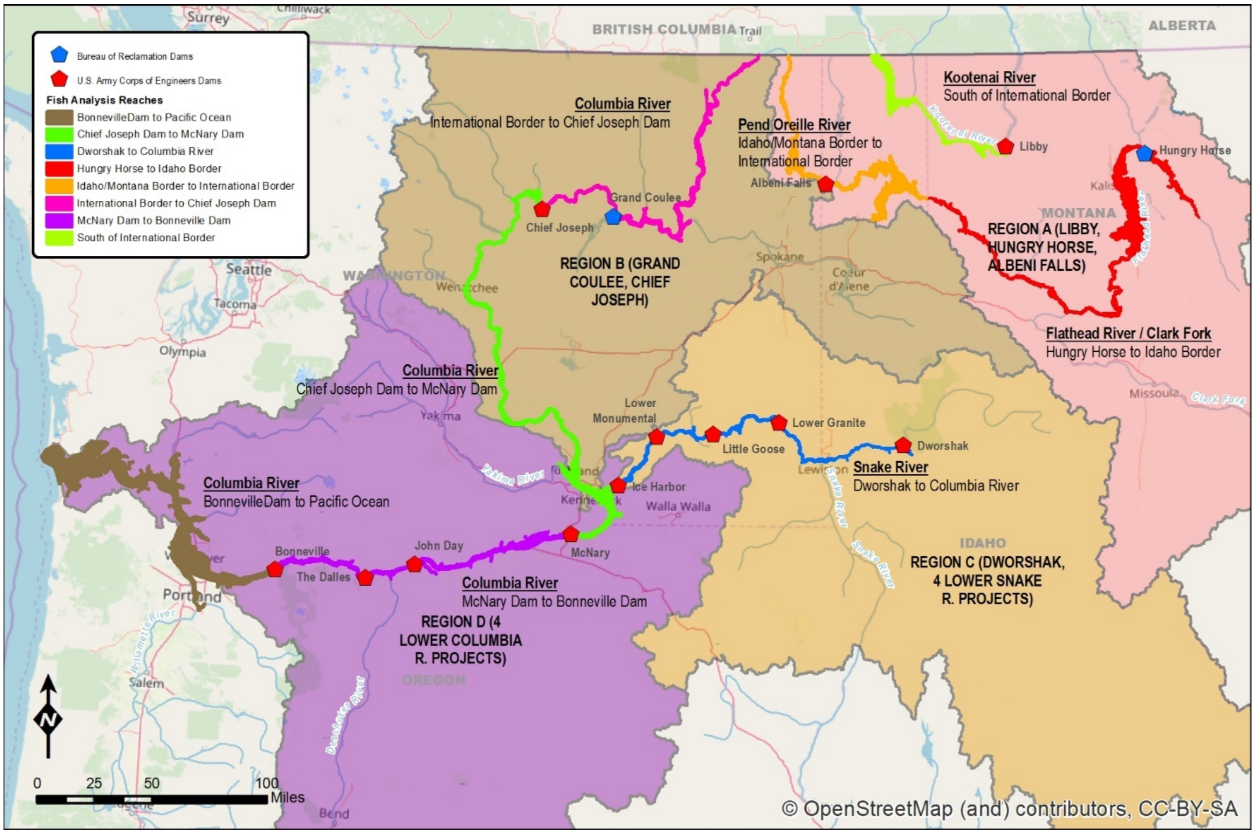



**Figure 3-109. Study Area Map**

Fish are characterized as either anadromous or resident. Resident fish are characterized as fluvial, adfluvial or non-migratory (see text box).

**What are the Common Fish Life History Forms?**

All fish use some kind of spawning and migration behaviors, often referred to as their "life history strategy." The fishes' life history determines its label of anadromous or resident, and if resident then it can be fluvial, adfluvial, or non-migratory.

**Anadromous:** As juveniles, fish migrate from freshwater to marine environments and then return to freshwater as adults to spawn. Eggs incubate in gravel and young fish emerge to rear in freshwater as they migrate downstream or prior to migration.

**Resident:** The entire life of the fish is within freshwater, in either streams, rivers, or lakes. Some species migrate to a different freshwater habitat for spawning having fluvial or adfluvial migration patterns, or can be called resident referring to no migration between spawning and rearing habitats.

**Fluvial:** These fish live entirely within flowing water and may migrate between larger rivers and smaller tributaries.

**Adfluvial**: Adults spawn and juveniles rear in freshwater streams but migrate to lakes for feeding as sub-adults, then migrate back to flowing water for spawning.

#### *3.5.2.2 Aquatic Habitat*

Features such as water quantity, quality, depth, velocity, cover, substrate, riparian and aquatic vegetation, and prey availability are all important components of aquatic environments that provide habitat for a diverse array of aquatic species. An overview of these features is described in this section, while species or location-specific features are discussed in individual species' sections. Water management operations at Columbia River System projects can affect these aquatic habitat features.

Aquatic habitat in this analysis is defined as all locations in the study area that are accessible to fish species. The existing conditions of the study area, which includes the 14 Federal dams, are influenced by surrounding areas and other projects upstream; these other projects are mentioned where relevant to the habitat under analysis.

Aquatic habitat can be divided into two categories: riverine habitat and reservoir/lake habitat. Each habitat hosts different species that have adapted to these conditions.

Analysis of the impacts of the MOs on aquatic habitat is described in the effects analyses for the specific fish species.

**AQUATIC HABITAT CATEGORIES**

**Riverine Habitats**

Rivers meander across their landscapes according to the underlying geological and physical features of the landscape, surrounding terrain, and dominant weather patterns.

A natural river ecosystem has a relatively stable pool-to-riffle ratio, which determines how and where the various plants and animals find their supporting habitats in channels and along shorelines. Riffles are key spawning locations; depth, velocity, and substrate determine spawning areas for salmon and steelhead, lamprey, and sturgeon. Pools support feeding areas for juvenile salmon and steelhead and holding areas for adult salmon and steelhead on upstream migration. Pools and riffles support different communities of invertebrates, which serve as prey items for fish and help with the important nutrient cycling process of the river ecosystem.

Along the riverine shorelines, beaches and sandbars form by deposition of suspended sand in zones of recirculating flow or eddies along the channel margin or by obstacles such as boulders and large logs in the channel that cause slower velocity water where sediment drops out of suspension. Juvenile fall-run Chinook salmon favor areas with gently sloping shorelines that are often associated with beach areas. Tiffan et al. (2006) found that along the Hanford Reach, the longest free-flowing reach of the Columbia River, subyearling fall-run Chinook salmon were most likely to occur in habitats with low lateral bank slopes with intermediate-sized gravel and cobble substrates.

Armoring, bulk-heading, dredging, filling, dock and pier construction, levee construction, riparian vegetation removal, and urbanization and industrialization have altered shorelines of importance to juvenile salmon during their freshwater migration downstream to the Columbia River estuary. Loss of shoreline aquatic vegetation and large woody material has reduced total habitat available for juvenile foraging, cover to hide from predators, and provision of insects and other detritus that flow into mainstem areas for food and cover.

In the riverine habitat immediately downstream from many of the dams, variations in flows as a result of power generation such as peaking and load factoring operations intermittently inundate and dewater the river shorelines. Downstream areas from storage projects experience more elevation changes due to peaking and load factoring operation than areas downstream of run-of-river projects. These river edges are nearly devoid of insect life and are biologically unproductive. When recolonization of aquatic life occurs during higher flows, subsequent reduction in flow can cause widespread stranding and desiccation of insects, small fish, and fish eggs, especially when it occurs rapidly. Flood pulses mimicking the natural flow regime, however, promote biological production and healthy ecosystems, whereas anthropogenic modifications of flows in temperate rivers typically reduce production (Junk, Bayley, and Sparks 1989). Intermittent high discharges can scour portions of the main channel, dislodging insects and their habitat. Frequent scour events below dams limit production in the zone protected by minimum flow requirements. The varial (drawdown) zone is an area of the upstream ends of a reservoir or river that is periodically inundated and dewatered as the pool or flow rate changes. The area typically lacks shoreline vegetation because perennial riparian vegetation or shallow aquatic vegetation establishment may be impaired and the community structure can diverge considerably from the reservoir bottom. Recruitment of large wood may be reduced. Historical habitats had dynamic flow regimes that fostered biological productivity by transporting terrestrial organic matter and nutrients to the riverine environment. Desiccation or other flow alternations outside the historical range can lead to less productive habitats. The manipulated flow regime of varial zones means they lack lasting, quality shallow-water habitat. With the change in habitat types from a productive, permanently wetted reservoir bottom to unproductive varial zone, the fish assemblage has also shifted. Desiccation of the river shorelines reduces aquatic insect populations that require wetted areas to complete their early life stages.

**Reservoir/Lake Habitats**

Each of the 14 Columbia River System projects has impounded a segment of river, thereby turning the flowing river into a more lake-like reservoir. Along the mainstem Columbia and Snake Rivers, about 486 miles of riverine habitat have been converted to lentic (still, freshwater) or semi-lentic reservoirs (Ebel et al. 1989). Dam construction has caused large-scale changes in habitat types that result in different species distribution, abundance, assemblages, suitability, productivity, and predator/prey relationships. These habitat changes have often favored non-native and/or invasive species that compete with and prey on native species.

Most reservoirs create three different habitat zones (Hjort et al. 1981). The first zone is the forebay area, which is typically lacustrine (lake-like) habitat. At the upstream end of the reservoir is a second zone that tends to be shallower and has substantial flow velocities. The third zone, between the forebay and the upstream end, is a transition area that changes from riverine at the upstream end to more lake-like in the downstream direction toward the forebay. Each zone can include several sub-types of habitat; however, most can be characterized as either backwater (including sloughs and embayments) or open-water habitats (Hjort et al. 1981; Bennett et al. 1983; LaBolle 1984).

Backwaters and embayments provide comparatively warmer temperatures, finer substrate, and submergent and emergent vegetation. The non-native resident fish species that spawn in these areas include bass, crappie, bluegill, pumpkinseed, yellow perch, northern pike, brown and black bullhead, and carp; for these species, spawning occurs from May through mid-July. Backwater areas support a greater concentration of zooplankton, which attracts the smaller fish species. This in turn attracts the larger predatory fish that prey on the smaller fish species. Open water is deeper, has less structure than the backwater areas, and has a range of water velocities. Species that spawn in open water include the non-native shad and walleye, as well as native minnows, suckers, sandroller, and white sturgeon. Non-native invasive predatory fish that spawn in the mainstem include walleye, bass, and channel catfish. The amount of juvenile salmonid predation by birds and native and non-native fish around dams depends on multiple factors. Species, proximity to suitable predator habitat, areas with delayed salmonid migration, and distance from avian colonies influence rates of predation (Petersen 1994; Venditti, Rondorf, and Kraut 2000; McHugh et al. 2011; Evans et al. 2016). In the lower Columbia River, marine mammals prey on adult salmonids and white sturgeon in the tailrace of Bonneville Dam; long-term trends of predation at Bonneville Dam and effects on populations are tracked annually (Tidwell et al. 2019). Research to measure and track the number of salmonids eaten by predators at Columbia River Basin dams and options to manage predation (e.g., predator removal or hazing to scare them away) is ongoing. General use of the project area by avian and marine mammal species described is in Section 3.6, Vegetation, Wetlands, and Wildlife.

Most of the native resident species spawn in flowing waters at the headwaters of the reservoirs or in tributary streams. Some species, however, also spawn in the reservoirs. For instance, northern pikeminnow will spawn either in flowing water or along gravel beaches in reservoirs (Wydoski and Whitney 1979). According to GEI Consultants Inc. (2004a), Lake Pend Oreille continues to provide good rearing habitat for cold water fish species; the Corps carefully manages Albeni Falls Dam operations to facilitate shoreline spawning habitat for kokanee salmon.

Project operations influence the lake-like conditions of reservoirs. The relatively shallow run-of-river reservoirs have short retention times (only a few days) while the storage reservoirs can have much longer retention times of more than 35 days. In run-of-river reservoirs, water is not stored so retention time does not change notably under different operations, and short retention time is conducive to faster travel times for outmigrating juvenile salmonids, which is beneficial for these species. In storage reservoirs such as Lake Roosevelt, however, retention time can be an important factor in providing habitat for the reservoir fish. Underwood and Shields (GEI 2004b) demonstrated that zooplankton density in Lake Roosevelt decreases as water retention time decreases below 30 days. Zooplankton is the primary food source for kokanee and for the fry life stage of many fish species. Therefore, dam operations that reduce water retention time and food availability for fish also reduce the lake's fish carrying capacity. Water retention time and reservoir elevation are the most important predictor of entrainment (unintentional passage of fish through turbines or spillways) of fish and nutrients through dams (McLellan et al. 2008).

As with riverine varial zones described above, biological resources such as plants, invertebrates, and fish cannot survive the periodic inundation and draining of the shoreline around reservoirs. These zones are impediments to migration as fish move into and out of tributaries that flow through the varial zone. This is particularly true in storage reservoirs with significant drawdowns. Increased flow from tributaries promotes juvenile emigration from streams into reservoirs, where they encounter a barren landscape with little cover and are particularly vulnerable to predation. Adults migrating into tributaries also encounter these barren reaches, which are highly dynamic and often pose physical impediments and render individuals especially vulnerable to predation. These varial zones are likely a major limiting factor to adfluvial species, such as redband trout and bull trout.

**AQUATIC HABITAT FEATURES**

**Water Quantity**

Water resources in the Columbia River System are carefully managed for multiple purposes to meet requirements for FRM, hydropower, irrigation, navigation, recreation, cultural resources, and to maintain an ecosystem that supports fish and wildlife. On average, more than 134 Maf of water flow through the Columbia and Snake River Basins annually. The lower flows each year occur from September through December, and peak flows occur in May and June with snowmelt from the higher elevations of the study area (Figure 3-110). An example hydrograph based on the 10-year average of outflows from Bonneville Dam from 2010-2019 appears below. For more detail on water flows and timing, see the descriptions in Section 3.2, *Hydrology and Hydraulics*.

Quantity and timing of flows are important for rearing and outmigrating juvenile salmon and steelhead, temperature regulation in certain river reaches, adult salmon and steelhead upstream migration, access to and preservation of spawning sites, and tributary connectivity. In addition, spawning and migratory behavior of resident species is influenced by quantity and timing of flows.

High spring runoff flows occur from April through June and are critical in moving juvenile salmon and steelhead out to the ocean. These flows also facilitate spawning behavior and migratory patterns of resident species such as white sturgeon and redband trout. These same flows allow adult salmon and steelhead to migrate upriver to natal spawning areas. During low water years, travel time for outmigrating juvenile salmon and steelhead is increased and survival reduced. Consequently, some of the water stored in upstream reservoirs is released to augment high spring flows to assist juvenile fish during outmigration. In addition, water stored for flow augmentation can be released from July through September to reduce adverse effects of high water temperatures and improve survival and migration success.

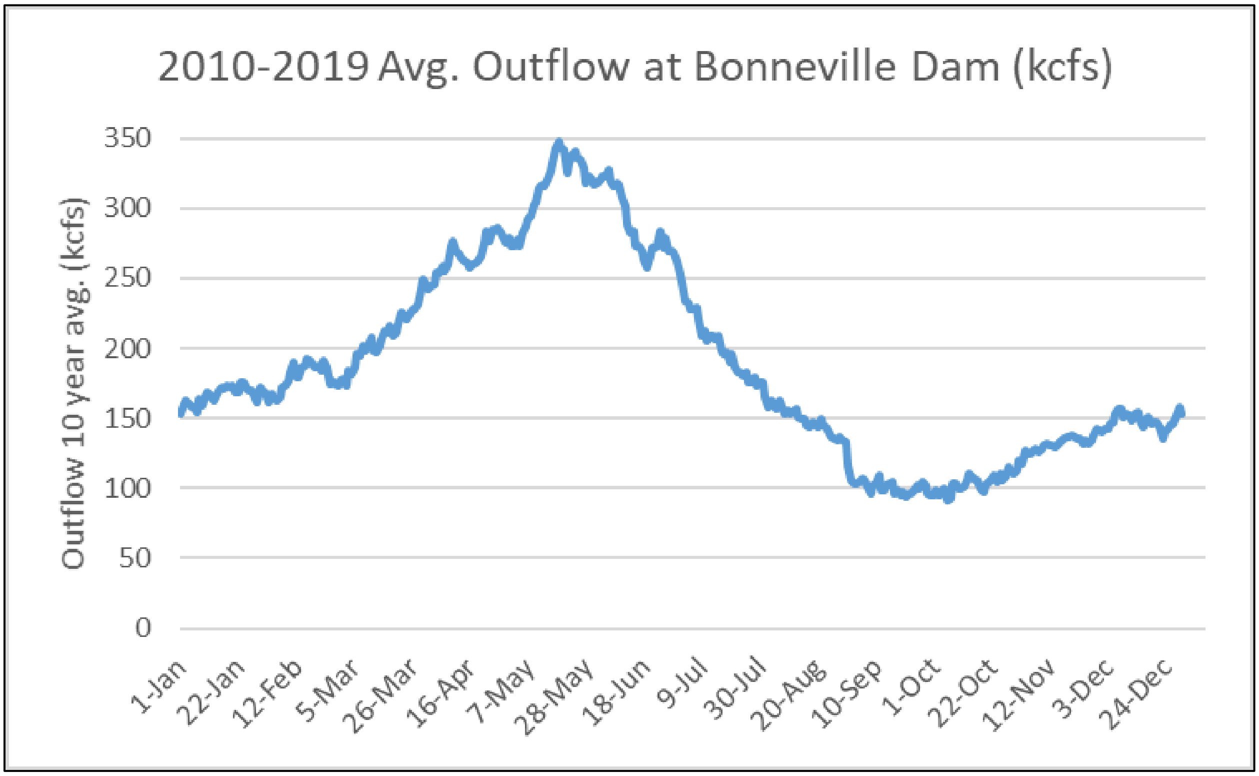



**Figure 3-110. Example Hydrograph Showing the Average Discharge throughout the Year at Bonneville Dam**

**Water Depth**

In some reaches, water depth is critical for fish to leave the mainstem rivers and access tributary habitat. Timing and quantity of discharge from dams can affect the depth of water for accessibility of some tributary habitats. One example of this is the minimum tailwater elevation at Bonneville Dam to allow chum salmon to access tributaries of the Columbia River near Ives Island.

In reservoirs and in connected floodplain aquatic habitats, the shallower backwater areas host the greatest abundance of fish in all life stages. Backwater and embayment areas provide slightly warmer habitat, finer substrate, and submergent and emergent vegetation. In reservoirs, the duration and depth of substrate inundation as the reservoir refills and drafts controls the annual production of benthic (bottom-dwelling) insects. Juvenile salmon and steelhead rear in areas of flowing water shallower than about 5 feet (1.5 meters [m]) and find bottom-dwelling aquatic insect larvae such as caddisflies, mayflies, and chironomids for food. Certain types of resident fish use shallow backwater and embayment areas of lakes and reservoirs.

Deep habitats support fewer fish compared to shallower areas. The majority of the species found in deeper waters are suckers and minnows; white sturgeon occur in deeper waters as well. Mid-depth habitats support a community higher in species diversity and abundance than deep habitat, but lower in abundance than shallow habitat (Bennett et al. 1991). In storage reservoirs, pelagic species such as kokanee occupy deeper habitats, exploiting rich zooplankton communities and production occurring within the euphotic zone (i.e., the depth in which sunlight penetrates).

**Water Velocity**

The habitat factors that influence water velocity are gradient, roughness, width, and depth of the river channel, lake, or reservoir. Roughness is determined by substrate coarseness such as sand, cobbles, or boulders, as well as any vegetation or other structures that affect flow. These habitat factors affect which species will use a given area of aquatic habitat. In the management of the 14 projects of the Columbia River System, water managers can control velocity to some extent through holding water or releasing it through the operating projects.

Water velocity and volume play a key role in the life cycle of salmon and steelhead and many other species. Water flow affects migratory movements of fish downstream and upstream. The timing of many runs of anadromous salmon and steelheads corresponds with peak flow (Collins 1892).

Decreased flow affects juvenile and adult migratory travel time, which increases their exposure to predation, elevated water temperatures, greater susceptibility to disease, and other sources of mortality and injury.

Water velocity also is a key factor in determining aquatic macroinvertebrate communities, which in turn determines whether fish can find an adequate quantity and variety of prey items. For example, the macroinvertebrates that are able to cling to rocks and graze algae can remain in faster-flowing water compared to the species that burrow into sand where water moves slower and deposits organic litter.

**Retention Time**

The retention time (RT) of a reservoir is the average time a water molecule will spend in that reservoir. RT is a theoretical value calculated as the ratio of reservoir volume to average flow (either inflow or outflow). The RT in a reservoir or lake is important because it influences several lake and reservoir behaviors including stratification (increasing with increasing retention time) and retention of nutrients (Straškraba 1999). When RT is short, the entire reservoir could become a riverine zone; when the RT is long it can be a more lacustrine (lake) zone (Straškraba 1999). Reduced retention times can result in increased entrainment of fish and food source out of the reservoir.

**Water Quality**

***Temperature***

Native fish species of the Columbia River Basin are adapted to cold flowing water, although some persist in slightly warmer temperatures in the lakes and reaches of the larger rivers. Each species and life stage can have a different range of tolerable and optimum temperatures. Most native species in the Northwest are cold water fish, and the introduced (non-native) species are warm water fish that tolerate and often thrive in the altered temperature regime that can be stressful for the native fish.

Warmer water temperatures generally occur in late summer and fall. These warmer temperatures increase the risk of native fish disease and mortality, affect their toxicological responses to pollutants, and can affect migratory movements because they can increase the body temperature of the fish. Water temperatures can be too cold, particularly in tailwater environments. These conditions may limit growth and productivity. Water temperatures can be influenced by a variety of factors including habitat, surface air temperatures, and water storage, inflows, reservoir surface area, solar radiation absorption, and diversions (Section 3.4, Water Quality).

Fish can move from an unsuitable water temperature into a cooler area to maintain control over body temperature. If available, juvenile and adult salmon will occupy water that is 13°C to 18°C, with the warmer water selected only when excess food is available. Water temperatures of approximately 23°C to 25°C can be lethal to salmon and steelhead, and salmonid eggs can die above 11°C (EPA 2001). Cold water refuges are areas in which the water temperature is colder than the predominant river temperature. These areas are important for salmon and steelhead as they migrate upstream, often in the warmest months of the year (EPA 2019). The Columbia River Cold Water Refuges Project, coordinated by the EPA, is designed to identify the cold water refuges currently available for use by migrating salmon, assess the sufficiency of the refuges for current and future populations, and identify strategies to restore, enhance, and protect high quality refuges for the future.

Dams and reservoirs can change water temperature through their effects on water velocity, water storage, water diversion, and irrigation return flows. The operation of dam and reservoir projects, withdrawal of surface waters for irrigation, and pumping of groundwater for irrigation alter the flow regime, most notably by dampening peak flows and impounding water and, thus, can influence water temperatures in the Columbia River System project areas. In some cases, water becomes warmer, and in other cases, cold water can be released from a project to reduce water temperatures downstream in the system such as from Dworshak Dam.

Surface waters in reservoirs can be warmed by the sun and air temperatures. However, water deeper in reservoirs, remains cold. Choices in operations, limited by the dam's configuration, can result in warm or cold water being released. Specifically, at Dworshak, Libby, and Hungry Horse Dams, selective withdraw depth gates area used to influence downstream water temperatures. These cold water releases are beneficial since historical temperatures in the lower Snake River basin prior to the construction of the lower Snake River dams and the Hells Canyon Complex show that temperatures in the free-flowing lower Snake River often exceeded 20°C in July and August and occasionally exceeded 25°C.[1] The warmer water temperatures occurring in late summer and fall, from a variety of factors, increase the risk of native fish disease and mortality, affect their toxicological responses to pollutants, and can affect migratory movements. Warmer water temperatures increase the foraging rate of predatory fish and help support habitat beneficial to invasive predatory fish. In fact, water temperature is probably the most important physical variable affecting the consumption rate and growth of predatory fishes (Brett 1979). For example, laboratory experiments demonstrated maximum consumption of salmon and steelhead prey increased from 0.5 smolts per day at 8.3°C to seven smolts per day at 21.7°C (Vigg and Burley 1990).

#### *Dissolved Oxygen*

Dissolved oxygen (DO) is a critical water quality component for all aquatic life. The daily cycling of photosynthesis and respiration is chiefly responsible for fluctuations in DO concentrations. Most aquatic animals need a minimum of five parts per million (ppm) of DO in water, although some species like carp, which are non-native in the system, can tolerate lower levels. The deep areas of reservoirs with high water retention times and limited vertical mixing can become oxygen depleted, which is harmful to fish and macroinvertebrates. During late summer of some years, high water temperatures (20°C to 22°C) and low DO levels (less than 6 ppm) have potential to cause direct mortality or deteriorate living conditions for native species in the Columbia River Basin.

#### *Total Dissolved Gas*

Plunging water over waterfalls, cascades, or dam spillways can cause downstream waters to become supersaturated with dissolved atmospheric gases referred to as supersaturated total dissolved gas (TDG), resulting from the entrainment of air bubbles into plunging water. The primary gases making up TDG pressure in water are oxygen, nitrogen, argon, and carbon dioxide. High TDG levels in water may persist for many miles downstream from their source. Elevated TDG can cause gas bubble trauma (GBT) in aquatic organisms, resulting in injury or death. GBT is an acute condition involving the growth of bubbles in the vascular system of the fish. Extreme cases of GBT are lethal. Dam operators try to control TDG by reducing spill to achieve less gas saturation in water. However, the severity of TDG supersaturation decreases by approximately 10 percent for every meter of water depth due to pressure. Migrating anadromous fish are typically quite mobile and may sound where adequate water depth is 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.

At the Lower Snake and Columbia River dams, spill is used to pass juvenile salmon downstream, limited the spill volume that produces 120 percent TDG saturation in the tailrace. Thus, TDG levels during April through June are 115 percent-120 percent throughout this reach as permitted by Oregon and Washington waivers to the Clean Water Act. Spill levels are lower in July and August at some dams, and the extent of high TDG waters is therefore reduced as well.

During high river discharges, uncontrolled spill can cause spill in excess of 120 percent TDG. Dam operators target certain operations intended to reduce adverse impacts, and to meet Clean Water Act limits of TDG by reducing spill or using certain spill patterns to achieve less gas saturation in water. The co-lead agencies have also constructed structural components of the dams in order to reduce adverse impacts of TDG, e.g. spillway flow deflectors.

***Pollutants***

The major pollutants in the Columbia River Basin are released from the adjacent landscape through urbanization and agricultural use of pesticides, fertilizers, and herbicides, as well as legacy contaminants from mining and industrial practices. On water activities such as navigation and recreation can also release contaminants. Oils and grease necessary for turbines and other machinery at the dam can leak into the river. The Corps and Reclamation applied for National Pollutant Discharge Elimination System permits for discharges of pollutants, including oil or grease, from appropriate point sources. These releases have resulted in increased pollutant loads moving through the Columbia River Basin, as well as lingering in settled sediments or by accumulation within resident plant and animal communities. Pollutants can disperse downstream through the Columbia River dams; some pollutants settle out when water slows down at a reservoir and others travel all the way to the estuary. Passing by a greater number of dams increases the chance of pollutants settling out and becoming part of the sediment.

***Turbidity***

Turbidity is an indicator of the amount of suspended particles in water. The particles are usually fine sediments of sand, silt, or clay but can be organic compounds such as plankton. Fish require specific levels of sediment and turbidity to hide from predators, but they also require clear waters to find their prey and have optimal gill function. The various native species in the Columbia River System have different ranges of tolerance for turbidity.

Flow regulation and the existence of reservoirs reduce turbidity in the rivers where Columbia River System dams are located. Turbid stormwater is held in reservoirs and released at a slower rate into clear water, compared to unimpounded rivers. This prolongs the duration of downstream turbidity, while reducing the intensity of downstream turbidity peaks. Reduced turbidity allows visual predators, such as smallmouth bass, to more effectively prey on native fish, such as juvenile salmon and steelhead.

Natural levels of turbidity are an important factor related to sturgeon migration, spawning, and survival. The reduced turbidity levels in reservoirs were linked to increased predation of white sturgeon larvae in laboratory studies (Gadomski and Parsley 2005).

**Substrate**

The capacity of any aquatic habitat to support fish and invertebrate populations depends largely on the substrate characteristics as well as depth and velocity of water, which in turn influence the size of substrate at the reach scale. The primary transport mechanism for water column sediment is surface water flow. Higher flows transport larger amounts of sediment with a wider range of particle sizes and weights while lower flows transport lighter, smaller particle fractions. Sediment particles settle in areas where flows and velocity decrease, such as backwater areas and impounded sections of the Columbia River System. Sediments fall out of suspension at a rate proportionate to their size and weight. This is why substrate in slower pool and glide habitats typically contains smaller materials than in faster riffle and run habitats, which often have enough power to keep smaller sediments in suspension.

Each fish species has adapted to spawn and feed in specific substrate types in combination with water velocity. Spawning substrate size preference varies by species and depends mostly on size of fish–larger fish can use larger substrates compared to smaller fish. For example, fall Chinook salmon in the Columbia and Snake Rivers use gravel beds with sediment size ranging from 1 inch (2.5 centimeters [cm]) up to 12 inches (30 cm) (Geist and Dauble 1998), whereas cutthroat trout select substrate sizes of 0.2 to 4 inches (0.6 to 10.2 cm) (Bjornn and Reiser 1991).

Sedimentation processes have been altered in the Columbia River Basin because of the construction of the Columbia River System and other projects. Many of the projects, particularly the storage projects, have interrupted the natural sorting regime of sediment. The mobilized bedload can only travel downstream to the next point at which the reduction in velocity means the river can no longer carry the larger grain sizes. USGS (1984) described downstream effects of dams showing that sediment concentrations and suspended loads decreased substantially for hundreds of miles downstream. Additionally, riverbed degradation varied from slight to 24 feet (7.5 m) deep with a coarsening of bed material and lengthened the degraded area over time extending to at least 30 years beyond dam construction and as much as 75 miles (120 kilometers [km]) beyond the dam site. One example of an issue created by changed sedimentation in the study area is that fine sediments that have accumulated in the lower 22 miles of the Flathead River have shifted the insect biota from a stonefly and mayfly assemblage to a midge-dominated community, which affects food availability for fish.

**Aquatic Vegetation**

Aquatic vegetation in rivers and reservoirs can be important habitat features for both fish and wildlife. Examples of fish habitat provided by aquatic vegetation include aquatic grasses in shallow reservoir areas providing spawning habitat to species that attach their eggs to vegetation, or predatory fish using cover to lie and wait for prey.

Much of the aquatic vegetation in the Columbia River, also known as macrophytes, that is in over-abundance is not native, and in many cases, it is detrimental to native fish communities through increases in water temperatures, cover for non-native predators, effects on flows, and tribal fisheries. Invasive aquatic plants are a problem in the basin and are on a trajectory for worsening unless aggressive management plans are implemented.

Aquatic vegetation as part of the affected environment is discussed further in Section 3.6, Vegetation, Wetland, and Wildlife.

**AQUATIC HABITAT CONNECTIVITY**

Connectivity, or the ability for aquatic species to access other aquatic habits, is an important part of species survival. Rivers play a vital role in connecting various terrestrial and aquatic habitats, and their value to all the plant and animal components of the ecosystem extends well beyond their surface area. Conversely, isolation of habitats has caused and can further risk extirpation of all the individuals in the confined space, which reduces overall abundance and biodiversity. For fish species, connectivity to different types of aquatic habitats is important for them to complete their chronological life stages, particularly for the anadromous species, which benefit from accessing the entire river system from the spawning area to the ocean.

The key aspect of longitudinal connectivity in aquatic habitat is the ability of fish to reach each type of habitat critical to its particular life stages. This primarily applies to the anadromous fish that travel long distances from the ocean up the large rivers to small tributaries, but also applies to some resident species that move between tributaries and reservoir habitats that can become disconnected at lower pool elevations. Longitudinal connectivity is important to prevent species fragmentation and to provide access to spawning, rearing, and foraging habitat for migratory fish (Fullerton et al. 2010). Loss of connectivity in the study area has led to the extirpation of multiple salmon populations and the continued fragmentation of resident fish populations. Conditions in the headwaters of rivers can have a direct effect on downstream habitats and organisms (Fullerton et al. 2010). In addition, longitudinal connectivity allows for transportation of sediment and nutrients in the form of woody debris, food items, and other organic matter.

Construction and operation of Federal and non-Federal dams in the Columbia River Basin have impacted longitudinal connectivity by blocking or otherwise affecting migratory fish corridors, changing stream flow patterns, and altering natural water temperature regimes that in many areas can cause delay of migration or even form thermal barriers.

Lateral floodplain connectivity in the context of aquatic habitat refers first to the ability of the river to move water into the adjacent landscape, and second, the ability of aquatic species to access aquatic habitats such as ponds, wetlands, and side channels. This connection between the river and its adjacent floodplain areas is important to many fish species to find appropriate habitat for spawning, rearing, and overwintering life stages. Many of the Columbia River System projects have eliminated floodplain habitat by inundating side channels and other important diverse types of habitats, or by altering flow regimes so that those floodplain habitats are no longer accessible by aquatic organisms.

#### *3.5.2.3 Anadromous Fish*

The affected environment for anadromous fish (Section 3.5.1) is organized by species in order to facilitate descriptions common to the species across specific runs throughout the Columbia River Basin. The environmental consequences analysis for anadromous fish (Section 3.5.2) is organized differently (Upper Columbia River, Middle Columbia River, Snake River, and Lower Columbia River) because the effects on those species are similar in these geographic areas.

The Columbia River Basin hosts many anadromous fish species. Anadromous fish use freshwater habitat for spawning and early juvenile life stages before migrating to marine waters to grow and mature for part of their lifecycle. Among the salmon and steelhead species, Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), sockeye salmon (*O. nerka*), and coho salmon (*O. kisutch*) are widespread in the Columbia River Basin. Chum salmon (*O. keta*) has a more limited distribution in estuary tributary streams.

Other anadromous fish include Pacific lamprey (*Enstophenus tridentatus*), eulachon (*Thaleichthys pacificus*), green sturgeon (*Acipenser medirostris*), and American shad (*Alosa sapidissima*). In addition, white sturgeon (*Acipenser transmontanus*) have a unique physiology that allows them to move regularly between fresh and saltwater. They are discussed in this document as resident fish, but the lower river populations are also known to move into the near-ocean environment to feed. Pacific lamprey have a widespread distribution in the region, migrating as far as the Clearwater and Salmon River tributaries of Idaho and the Methow subbasin in the upper Columbia River. Green sturgeon, by contrast, have a relatively limited distribution in the Columbia River Basin, only migrating upstream to about the city of Longview, Washington, well below Bonneville Dam. American shad are the only non-native anadromous species in the Columbia River Basin.

Migratory salmonids are important vectors of energy and nutrients between marine and freshwater ecosystems. For example, anadromous fish carry nutrients across habitat boundaries, and they influence community and food web structure in aquatic as well as terrestrial ecosystems (Gende et al. 2002). Spawning salmon contribute an estimated 5 to 95 percent of the nitrogen and phosphorus in salmon-bearing streams (Gresh et al. 2000). Anadromous fish deliver resources that affect food web productivity and influence a diverse array of flora and fauna across vast landscapes in the Columbia River Basin (Naiman et al. 2002).

Anadromous salmon and steelhead returns can vary widely from year-to-year and as shown in Figure 3-111, as recently as 2014, salmon and steelhead were returning to Bonneville Dam on their way to upstream tributaries in numbers not been seen in many decades. As the ISAB noted in 2016 "More salmon returned from the Pacific Ocean and were counted crossing Bonneville Dam, 146 miles inland, on their way to spawn—at hatcheries or in the wild—in 2014 than in any year since 1938, when fish counting began there. The 2014 run was about 2.5 million fish, continuing the trend of big returns in the 21st Century compared to the 1990's" (ISAB, 2015-1). During that same period, NMFS noted in their 2016 5- year status review of Pacific salmon and steelhead that wild Snake River spring Chinook salmon abundance had increased over the levels reported in their prior review for most populations, although the increases were not substantial enough to change viability ratings. NMFS attributed the relatively high ocean survival in recent years as a major factor in the abundance patterns leading up to their 2016 review (NMFS, 2016). Although the number of adult salmon and steelhead has declined since 2014, even with consistent operations of the CRS, and NMFS's 2020 status review will encompass years with lower returns and declining ocean conditions, these returns show that salmon and steelhead can pass upstream and downstream through the system in its current configuration when conditions are suitable.

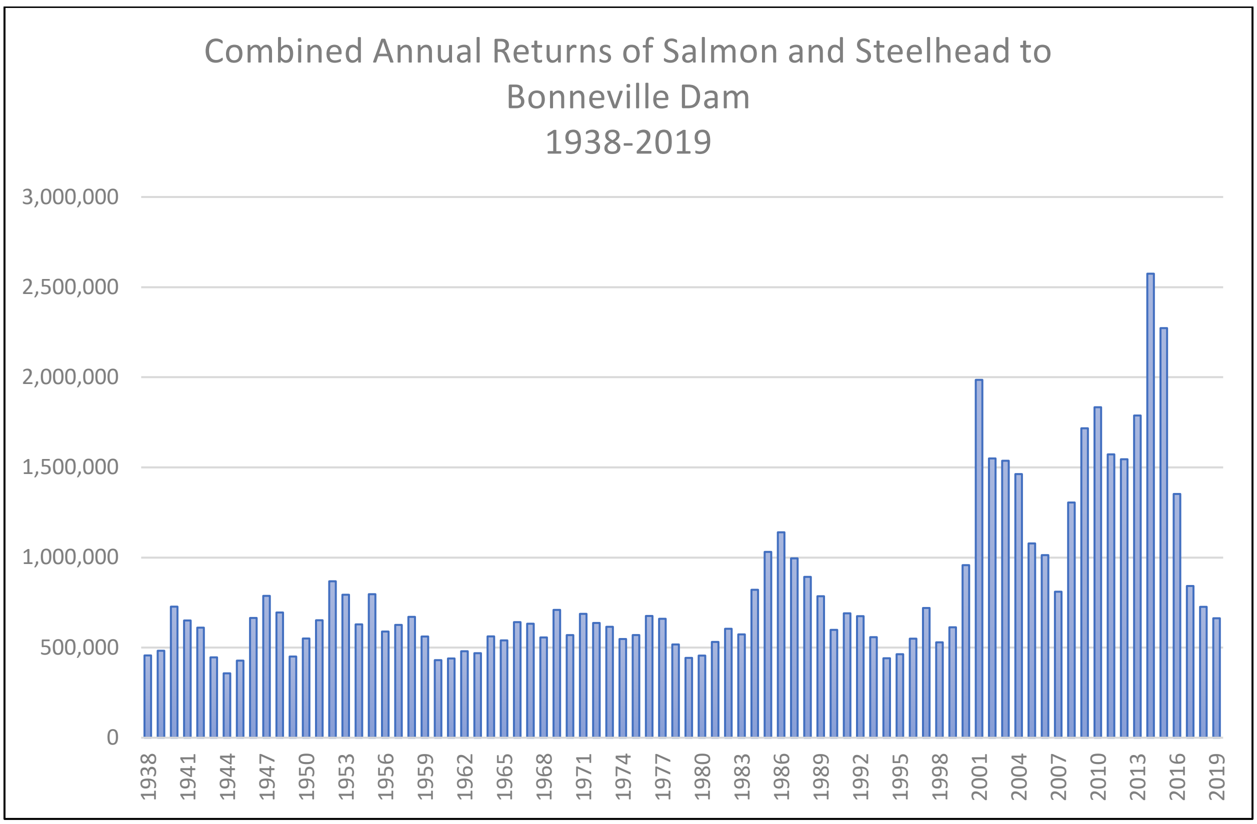



**Figure 3-111. Combined Annual Salmon and Steelhead Returns (all species) to Bonneville Dam from 1938-2019.**

These returns are a combination of hatchery and natural origin fish. (Data Source: University of Washington-Data Access Real Time (DART) tool)

On February 4, 2020, the co-lead agencies viewed a presentation prepared by NMFS regarding returns for the 2019 fish passage season and the Adaptive Management Implementation Plan.[2] Although not all returns occurred prior to the presentation, NMFS utilized current return numbers to project return numbers if current return rates continued in 2020 and 2021. These projections signaled that returns are low, especially for Snake River steelhead. The co-lead agencies are currently evaluating the information provided by NMFS and will have a more detailed discussion of this information in the final EIS, including any updates that NMFS may provide once all returns have occurred, if appropriate.

To aid the downstream passage of juvenile salmon and steelhead, the co-lead agencies have worked to improve passage and survival past the dams and through the reservoirs of the CRS. Figure 3-112, shows recent estimates of survival at the eight lower CRS projects with fish passage. The dam survival estimates do not include systemwide or latent effects (see section 3.5.3.1). These estimates were developed show progress towards meeting the individual dam survival goals developed during the 2008 Biological Opinion of 96 percent survival past each dam for yearling Chinook and steelhead, and 93 percent for Snake River sub-yearling fall Chinook. In their 2017 analysis of system improvements used for recovery planning analysis, NMFS concluded that:

> "In summary, recent average annual reach survival estimates for migrating smolts have improved substantially compared to the 1980-2001 Base Period for Snake River steelhead, yearling spring/summer Chinook salmon, and sockeye salmon (by roughly 50-75 percent) and compared to the 1998-2005 earlier period for subyearling hatchery fall Chinook salmon (about 35 percent). As noted in the 2010 Supplemental Biological Opinion (NMFS 2010; see also Section 2.2.2.2), on a per-kilometer basis, these survival rates are approaching those estimated for several free flowing river systems. Controlling for other factors affecting adult returns such as poor ocean conditions, these increased average survival rates for inriver migrating smolts have resulted in higher adult returns in recent years compared to the Base Period" (NMFS, 2017).

Adult upstream passage through the CRS projects on the lower Columbia and lower Snake Rivers is generally safe and effective. As NMFS noted in 2017,

> "Adult salmon and steelhead can pass each of the eight mainstem dams in the lower Snake and Columbia rivers volitionally at fish ladders (also called "fishways"). In general, we consider these adult passage facilities to be highly effective. For example, the current estimate of average adult Snake River spring/summer Chinook salmon survival (conversion rate estimates using known-origin adult fish after accounting for "natural 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.

2016) is approximately 87.3 percent, or 73.7 percent when harvest and straying are included ….” (NMFS, 2017)

Figure 3-113 displays the trends described by NMFS for Snake River stocks and reflects the combination of passage, straying, and harvest. Once adult salmon and steelhead pass the furthest upstream dam in their migration, there may continue to be losses influenced by a combination of many factors including natural mortality, water quality, straying, and harvest.

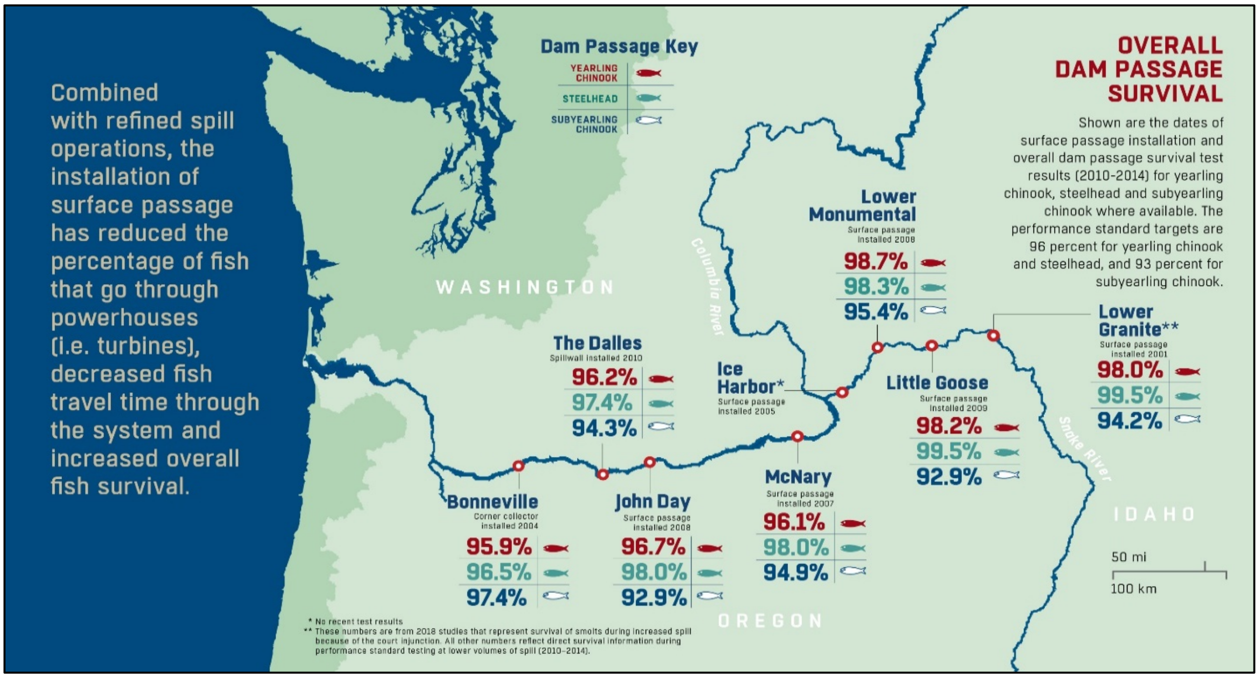



**Figure 3-112. Recent Estimates of Dam Survival at Columbia River System Projects**

Note: These dam-specific survival estimates do not include systemwide or latent effects.

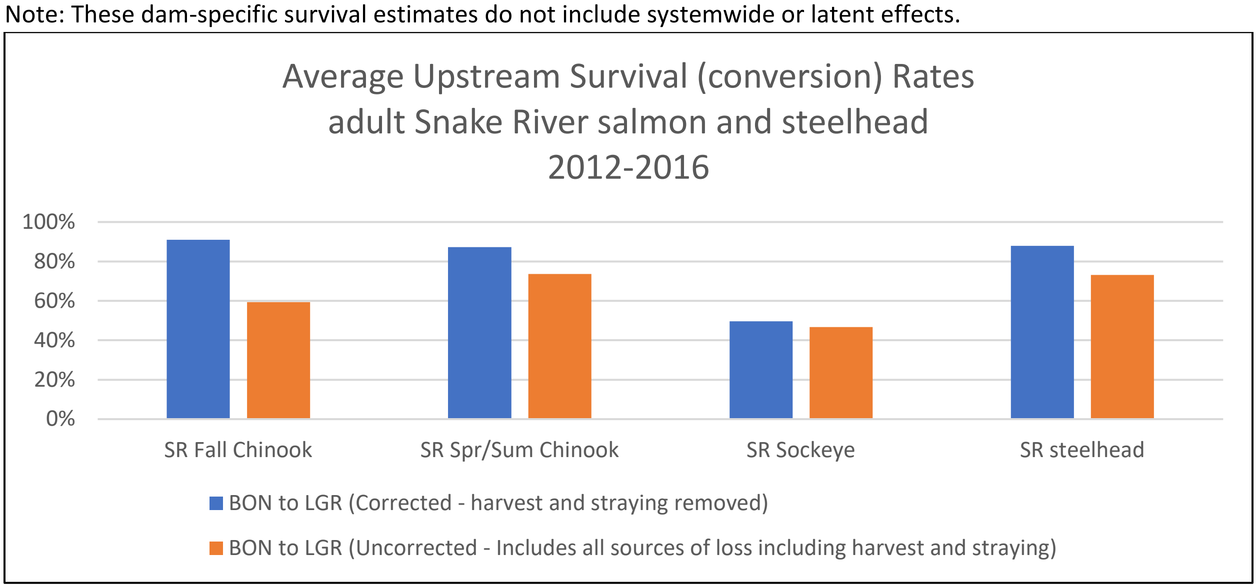



**Figure 3-113. 2015–2019 Snake River Spring/Summer Chinook Salmon Upstream Survival Rates**

Figure is based on data from NMFS (2017).

## ENDANGERED SPECIES ACT–LISTED ANADROMOUS FISH

An inventory of the ESA-listed anadromous species and their designated critical habitat in the study area appears in Table 3-57. Details on distribution, population status, and threats to each of these species appear in the *Federal Register* notices that National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) provide for all listing actions; these are cited in the table. Species status and relevant CRSO study area information appears in their respective subsections later in this section.

**What are Evolutionarily Significant Units and Distinct Population Segments?**

ESA-listed fish species may be identified as an evolutionarily significant unit (ESU) or a distinct population segment (DPS). Scientists developed the concepts of ESU and DPS to define a listable population unit according to ESA policy for Pacific salmon (56 *Federal Register* [FR] 58612).

An ESU or DPS is a vertebrate population or group of populations that meet certain criteria of being discrete or isolated from other populations of the species and significant to preservation of the genetic diversity of the species (61 FR 4722). These designations can apply to populations within the species if these conditions occur: (1) they are substantially isolated from other populations of the same species due to physical, physiological, ecological, or behavioral separation; and (2) the population or group represents an important component required to maintain conservation of genetic diversity of the biological species per the ESA regulations (61 FR 4722). Typically, DPS is used for steelhead and inland species, and ESU applies to salmon.

**Table 3-57. Status and Critical Habitat of Anadromous Columbia River Basin Endangered Species Act–Listed Species**

| Species and ESU or DPS | | ESA Listing Status | Critical Habitat Designation |
|---|---|---|---|
| Chinook salmon | Upper Columbia River Spring-run ESU (*Oncorhynchus tshawytscha*) | Endangered 1999 | 2005 |
| | Snake River Spring/Summer-run ESU (*O. tshawytscha*)[1/, 2/] | Threatened 1992 | 1993 |
| | Snake River Fall-run ESU (*O. tshawytscha*)[1/] | Threatened 1992 | 1993 |
| | Lower Columbia River ESU (*O. tshawytscha*) | Threatened 1999 | 2005 |
| | Upper Willamette River ESU (*O. tshawytscha*) | Threatened 1999 | 2005 |
| Steelhead | Upper Columbia River DPS (*O. mykiss*) | Endangered 1997; re-classified to threatened 2006 | 2005 |
| | Snake River Basin DPS (*O. mykiss*)[2/] | Threatened 1997 | 2005 |
| | Middle Columbia River DPS (*O. mykiss*) | Threatened 1999 | 2005 |
| | Upper Willamette River DPS (*O. mykiss*) | Threatened 1999 | 2005 |
| | Lower Columbia River DPS (*O. mykiss*) | Threatened 1998 | 2005 |
| Coho salmon | Lower Columbia River ESU (*O. kisutch*)[3/] | Threatened 1999 | 2016 |

| **Species and ESU or DPS** | | **ESA Listing Status** | **Critical Habitat Designation** |
|---|---|---|---|
| Chum salmon | Columbia River ESU (*O. keta*) | Threatened 1999 | 2005 |
| Sockeye salmon | Snake River Basin DPS (*O. nerka*)[4/] | Endangered 1991 | 1993 |
| Eulachon | Southern DPS (*Thaleichthys pacificus*) | Threatened 2010 | 2011 |
| Green Sturgeon | Southern DPS (*Acipenser medirostris*) | Threatened 2006 | 2009 |

1/ State-listed threatened: Oregon (Oregon Administrative Rule [OAR] 635-100-0105).
2/ State-listed threatened: Idaho (Idaho Administrative Procedures Act [IDAPA] 13.01.06).
3/ State-listed endangered: Oregon (OAR 635-100-0105).
4/ State-listed endangered: Idaho (IDAPA 13.01.06).
5/ State-listed species of concern: Montana (Montana Fish, Wildlife and Parks [MFWP] 2018).

### Salmon and Steelhead

Considerable scientific literature is available on ESA-listed salmon and steelhead species in the Columbia River Basin, including the life history of these species, how fish migrate through Columbia River System projects to and from the ocean, migratory timing, abundance, and in some cases, survival rates passing the dams. Additional information on existing conditions for fish regarding Columbia River System operations and configurations is provided in NMFS biological opinions (NMFS 2008a, 2010a, 2014a, 2019).

Multiple factors have contributed to the historical decline and current status of salmon and steelhead. The construction and operations of the Columbia River System are among the many factors that have adversely affected these species. The adverse impact of past Columbia River System operations has been reduced over time, and multiple mitigation actions have improved habitat, hatchery operations, and predator management, thus increasing survival rates of individuals in these ESUs, reducing extinction risk, and thereby contributing to improvements in the likelihood of recovery.

As adults migrate upstream and juveniles outmigrate, they negotiate up to eight CRS project dams, as well as other non-Federal facilities. Factors such as migration delays, fallback, encounters with powerhouse facilities, TDG, and water temperatures can all affect the survival of anadromous fish.

Metrics used to track these factors include the following:

- Juvenile travel time
- Juvenile in-river survival
- Dam passage survival
- Powerhouse encounters
- Water particle travel time
- Mortality from GBT

For some species, information is available to track population level metrics such as adult abundance (returning adults to a given population), and smolt-to-adult return ratios.

As a group, salmon and steelhead are diverse in their biology, exhibiting a range of life history and reproductive strategies. Terms that are used in this EIS to describe each species include descriptors of the migratory patterns of salmon and steelhead and the reproductive types. Reproductively, salmon and steelhead tend to reproduce once before dying (semelparous), but some steelhead and other fish can reproduce multiple times (iteroparous).

Anadromous fish hatch from eggs in freshwater, then migrate to the ocean while undergoing the physiological process of smoltification to grow and mature, and then return to freshwater as adults to spawn. Non-anadromous fish remain in freshwater throughout their life cycle. Pacific salmon and steelhead are largely anadromous, although there are non-anadromous forms (e.g., non-anadromous sockeye are called kokanee, and non-anadromous steelhead are called rainbow or redband trout).

The terms ESU and DPS comprise one or more populations as a “species” under the ESA. A population of fish is a group of the same biological species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season (McElhany et al. 2000). The ESA terms ESU and DPS comprise one or more populations, as the key feature of an ESU or DPS is reproductive isolation from other groups in that same species.

Juvenile salmon and steelhead originating above Bonneville Dam migrate downstream through as many as eight Columbia River System projects, and the same is true for adult salmon and steelhead returning to spawning grounds in the opposite direction. Migration habitat features important to salmon and steelhead as they migrate through the Columbia River and lower Snake River reaches include water quality, water temperature, water velocity, passage survival, adult fallback (i.e., deviation from upstream migration to move back downstream through dams already ascended), and factors that may influence delayed mortality.

#### *Chinook Salmon*

Chinook salmon are the largest of the Pacific salmon and are known by many names, most commonly king salmon, or Chinook salmon. Chinook salmon have an anadromous life history (although non-anadromous males and landlocked populations do occur) and are semelparous. Age at maturity is highly variable among populations, but most Chinook salmon on the West Coast spawn at 3, 4, or 5 years of age. Chinook salmon are classified into two life history types: stream-type and ocean-type. These life history types have several ecological differences, but the most basic difference is how long the juveniles spend in the freshwater habitat prior to migrating out to the ocean; stream-type juveniles outmigrate as yearlings, whereas ocean-type juveniles outmigrate much younger and may spend substantial time in the estuarine environment below Bonneville Dam before entering the ocean environment. In the Columbia River Basin, Chinook salmon occurring west of the Cascade Crest tend to be primarily ocean-type (Myers et al. 1998). Chinook salmon occurring east of the Cascade Crest include both stream-type and ocean-type races, with the stream-type occurring in the Deschutes, John Day, Yakima, Wenatchee, Entiat, and Methow Rivers (Myers et al. 1998).

Chinook salmon stocks are often described as seasonal "runs." In the Columbia River Basin, there are spring-run, summer-run, and fall-run Chinook salmon stocks. The run refers to the time of year that the adults return to freshwater to start their spawning migration.

Six Chinook salmon ESUs are within the scope of this EIS (Myers et al. 1998):

- Upper Columbia River spring-run (ESA-listed endangered, further discussed in this section)
- Snake River spring/summer-run (ESA-listed threatened, further discussed in this section)
- Middle Columbia River spring-run (not ESA-listed)
- Upper Columbia River summer/fall-run (not ESA-listed)
- Snake River fall-run–ESA-listed (ESA-listed threatened, further discussed in this section)
- Lower Columbia River–ESA-listed (ESA-listed threatened, further discussed in this section)

**Life Histories: What are the Different Migration Timings of Chinook Salmon?**

**Stream- and ocean-types:** Chinook salmon can follow either stream- or ocean-type freshwater life history strategy. Stream-type Chinook salmon reside in freshwater for a year or more before migrating to the ocean as larger juveniles. Ocean-type Chinook salmon migrate to the ocean within their first year after emerging from the gravel.

**Run timing:** Salmon runs are named for the season when the adult fish return to their home estuary.

Spring-run Chinook salmon use the stream-type strategy as juveniles, then spend 1 to 4 years maturing in the ocean before returning to freshwater as immature fish (also called early or bright fish) from March through May. They migrate upriver, mature in suitable refuges for several months (March to June), and spawn in late summer and early fall (August to September).

Fall-run Chinook salmon use the ocean-type strategy as juveniles, then spend 1 to 5 years maturing in the ocean before returning to freshwater. They enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas, and spawn within a few days or weeks of freshwater entry (late September to November).

**Tules and upriver brights:** Tules are sexually mature fall-run Chinook salmon and spawn in lower Columbia River tributaries. Upriver brights are fall-run Chinook salmon upstream of The Dalles Dam.

<u>Upper Columbia River Spring-Run Chinook Salmon</u>

Upper Columbia River spring-run Chinook salmon extant populations include all naturally spawned populations of Chinook salmon in Columbia River tributaries downstream of Chief Joseph Dam and upstream of Rock Island Dam, excluding the Okanogan River. This includes populations spawning in the Wenatchee, Methow, and Entiat Rivers, and the progeny of six artificial propagation programs. These fish spawn above the confluence of the Snake River and pass through four Columbia River System projects, including Bonneville, The Dalles, John Day, and McNary Dams. They also pass up to five non-federal Public Utility District (PUD) owned mainstem dams (Rocky Reach Dam and Rock Island Dam are owned and operated by Chelan County PUD while Wanapum Dam and Priest Rapids Dam are owned and operated by Grant County PUD), and Wells Dam is operated by Douglas County PUD). Annual upper Columbia

River spring-run Chinook salmon returns at Rock Island Dam averaged 3,714 fish between 2010 and 2016 and ranged from 2,167 to 6,090 fish (Oregon Department of Fish and Wildlife [ODFW] and Washington Department of Fish and Wildlife [WDFW] 2017).

Upper Columbia River spring-run Chinook salmon have unique run timing, both as juveniles and adults. Juveniles follow a stream-type freshwater cycle, meaning that they outmigrate after 1 year of rearing in freshwater during mid-spring through early summer (NMFS 2018). Returning adults enter freshwater beginning in early spring, with the peak run occurring in mid-May, and the fish reach upper Columbia River tributaries from April through July. Some males return to natal streams after one winter at sea; however, the 4- and 5-year-old adults represent the majority of the run.

This ESU's adult return run timing in early spring makes them subject to relatively higher predation from seals and sea lions (pinnipeds) compared to other salmon species because most of these pinnipeds arrive in the area downstream of Bonneville Dam in March and April and leave by early summer.

The adults then hold in tributaries until spawning in the late summer, peaking in mid-late August (NMFS 2016). After spawning, the adults' health declines rapidly and they die within a few days (Figure 3-114).

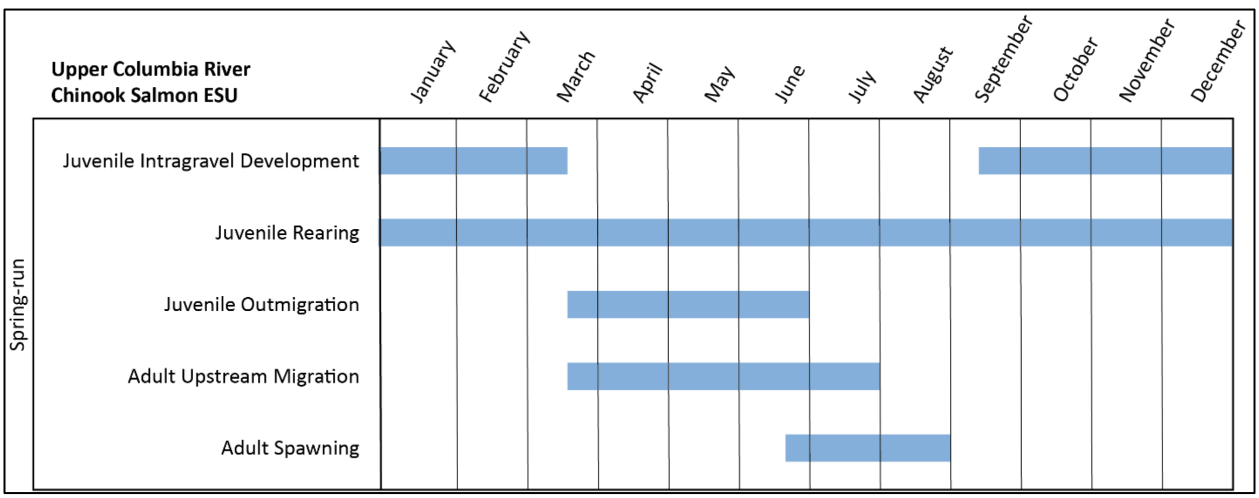



**Figure 3-114. Freshwater Life Phases for Upper Columbia River Spring-Run Chinook Salmon Evolutionarily Significant Unit**

Source: NMFS (2007, 2018)

<u>Lower Columbia River Chinook Salmon</u>

The lower Columbia River Chinook salmon ESU includes all naturally spawned populations from the mouth of the Columbia River upstream to and including the White Salmon River in Washington and the Hood River in Oregon. This ESU also includes the Willamette River upstream to Willamette Falls (exclusive of spring-run Chinook salmon in the Clackamas River), and 15 artificial propagation programs. Bonneville Dam is the only mainstem system facility within the lower Columbia River Chinook salmon ESU range (NMFS 2013). Lower Columbia River Chinook salmon might migrate through other non-Columbia River System dams depending on their spawning locations, rearing, and migratory movements (NMFS 2016).

This ESU follows an ocean-type life history with three distinct patterns based on their return to freshwater: spring-run Chinook salmon, fall-run Chinook salmon, and late fall-run Chinook salmon (NMFS 2013). These three components of the Lower Columbia River Chinook Salmon ESU all have similar ocean distributions but are exposed to different in-river effects because of migration timing (NMFS 2016).

Lower Columbia River spring-run and late-fall-run juvenile Chinook salmon exhibit a stream-type maturation that depart in the fall and early winter when they overwinter in larger rivers before outmigrating the following spring as yearlings. In contrast, lower Columbia River fall-run Chinook salmon exhibit an ocean-type maturation life history; juveniles emigrate as subyearlings in late summer or autumn and rely heavily on the Columbia River estuary before continuing to the ocean (NMFS 2013). Spring-run Chinook salmon enter freshwater from January through May before spawning from September to October. Fall-run Chinook salmon enter freshwater from August to October and spawn nearly immediately from October through December. Late-fall-run adults enter freshwater from August to November and spawn from November through January (NMFS 2013; Figure 3-115).

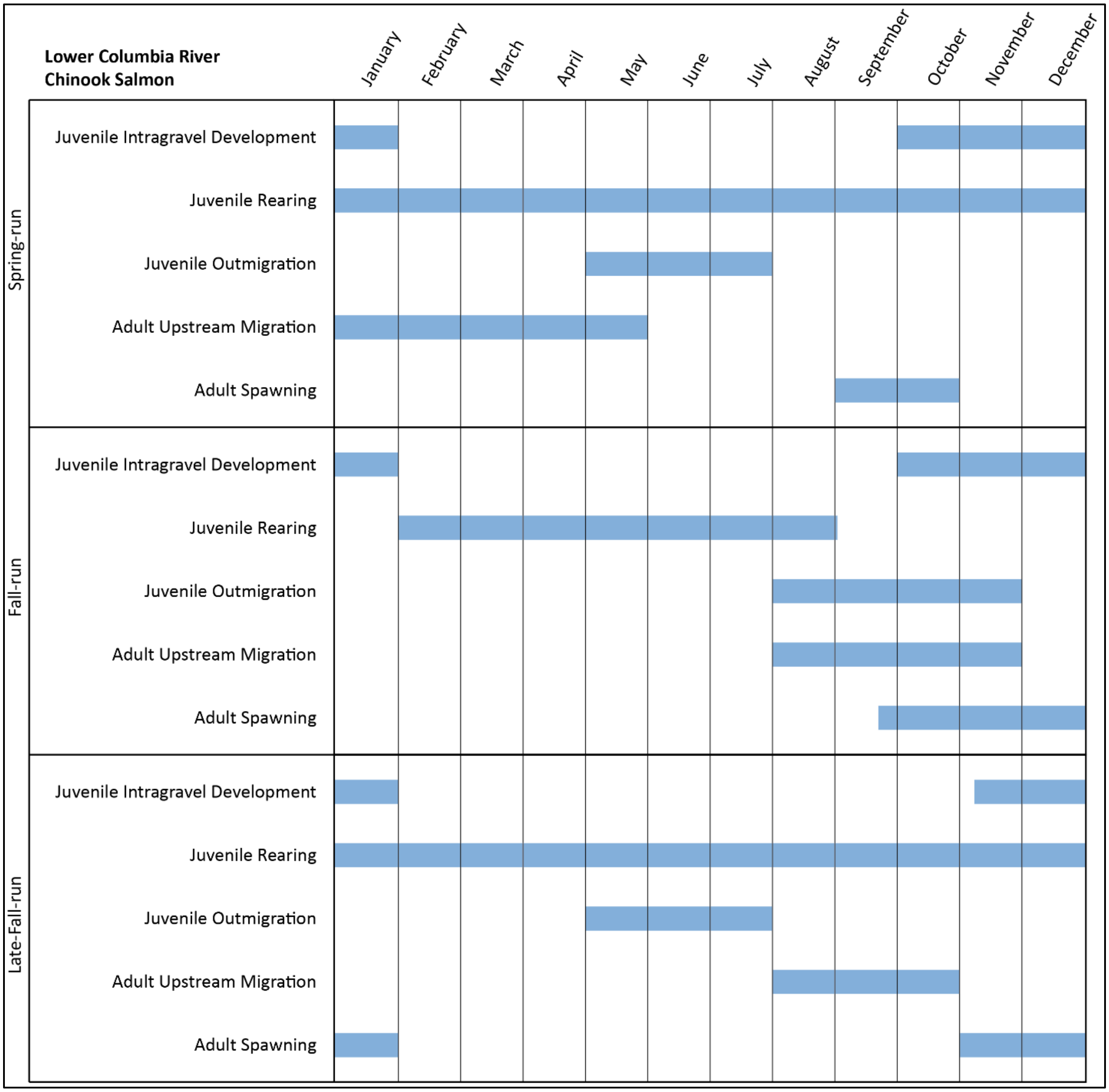



**Figure 3-115. Freshwater Life Phases of Lower Columbia River Chinook Salmon Evolutionarily Significant Unit**

Source: NMFS (2013)

<u>Snake River Spring/Summer Chinook Salmon</u>

The Snake River spring/summer Chinook salmon ESU includes all naturally spawned populations of spring/summer Chinook salmon in the mainstem Snake River and the Tucannon River, Grande Ronde River, Imnaha River, and Salmon River subbasins (NMFS 2016e), and the progeny of 15 artificial production programs.

Two distinct forms are recognized for Snake River Chinook salmon: the spring-run and the summer-run; these are distinguished when adult Chinook salmon move through the estuary and ascend Bonneville Dam in their spawning migration (Figure 3-116). Both spring-run and summer-run Chinook salmon display a stream-maturing life history meaning adults enter freshwater sexually immature and require a few months in rivers and tributaries to mature prior to spawning (NMFS 2017a). Spring-run Chinook salmon enter freshwater primarily from March through May and migrate to spawning reaches, then spawn in mid- to late August with some spawning extending into early September. Summer-run Chinook salmon enter freshwater primarily from June to July and wait to migrate to spawning areas until late summer. Some adults from both runs might hold in deep pools before completing their spawning migration.

Snake River Chinook salmon juveniles (both spring-run and summer-run) migrate to the ocean from mid-April through early June, with peak migration in mid-May (NMFS 2017a). Spring- and summer-run Chinook salmon juveniles have limited variability for rearing in their natal streams, but higher variability for the marine life stage, typically between 1 to 3 years.

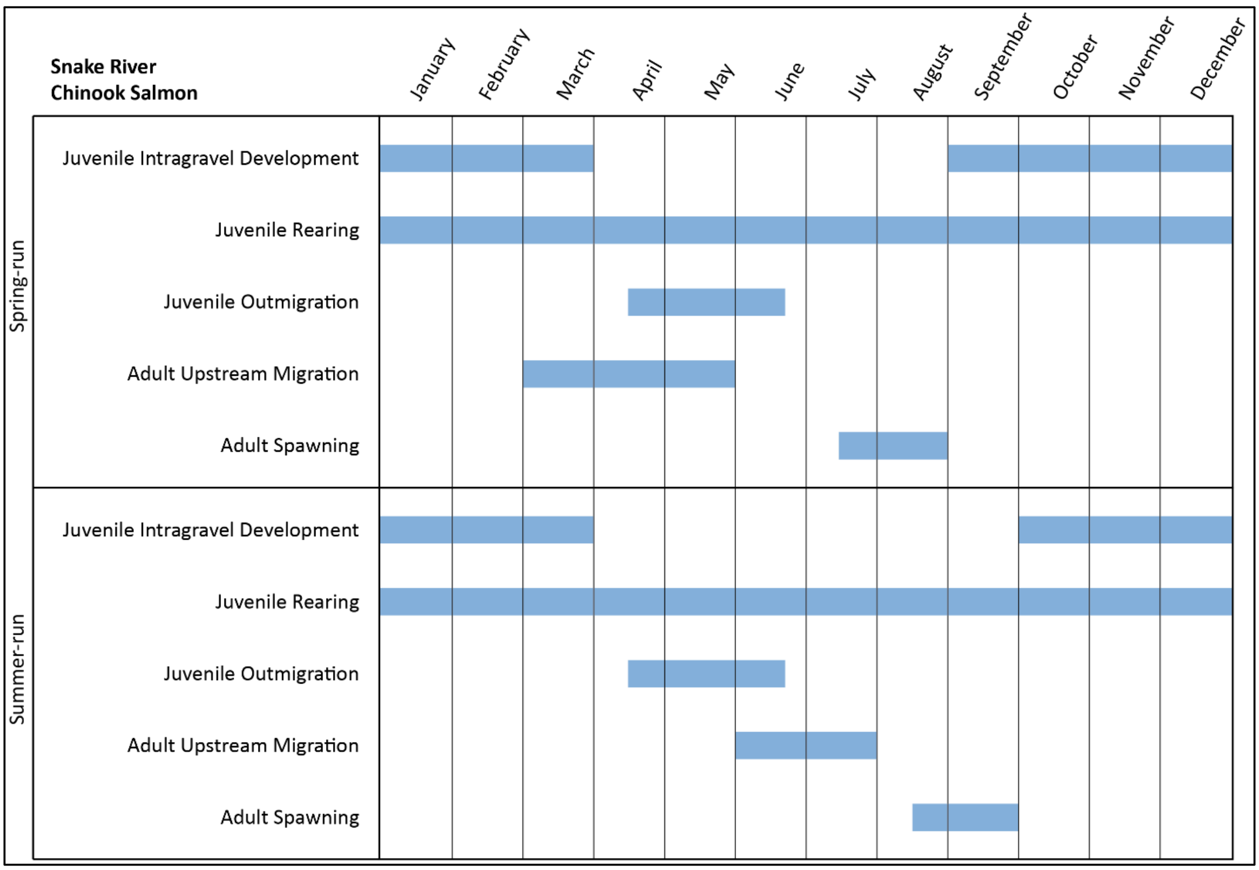



**Figure 3-116. Freshwater Life Phases of Snake River Spring/Summer-Run Chinook Salmon Evolutionarily Significant Unit**

Source: NMFS (2017)

<u>Snake River Fall Chinook Salmon</u>

The Snake River fall-run Chinook salmon spawns in the mainstem of the Snake River, Clearwater River, and major tributaries.

Snake River fall-run Chinook salmon follow an ocean-type life history; however, some fish in this ESU delay seaward migration and enter the ocean as yearlings and are referred to as having a reservoir-type life history (Connor et al. 2005). The majority of Snake River fall-run Chinook salmon juveniles of wild and hatchery origin migrate to the ocean before mid-summer as subyearlings, and some wild-origin fall Chinook salmon outmigrate in late summer including September (Figure 3-117). An exception are the Snake River fall-run Chinook salmon that migrate as yearlings and primarily originate from the Clearwater River basin (NMFS 2017). Water temperature influences the rate of development and life history of Snake River fall-run Chinook salmon, particularly for juveniles. Adult Snake River fall-run Chinook salmon enter the Columbia River from early August to September and reach the Snake River between mid-August and mid-October. Adults then spawn in the Snake River and tributaries through early December.

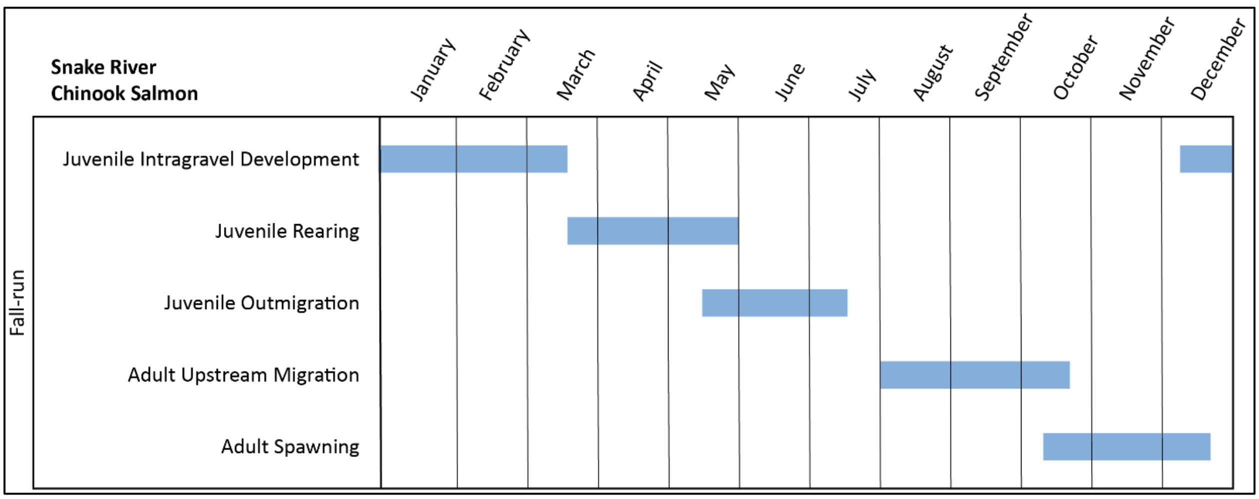



**Figure 3-117. Freshwater Life Phases of Snake River Fall-Run Chinook Salmon**

Source: NMFS (2017)

### *Sockeye Salmon*

Sockeye salmon are also called blueback and red salmon. The Columbia River Basin is the southern extent of the species on the West Coast (Gustafson et al. 1997). Sockeye salmon have anadromous and non-anadromous life history types; non-anadromous sockeye salmon, known as kokanee, are addressed in the Resident Fish sections of this EIS. There are three anadromous forms of sockeye salmon: lake-type, river-type, and sea-type (Gustafson et al. 1997). Sockeye salmon in the Columbia River Basin are lake-type and spawn in either inlet or outlet streams of lakes or in lakes themselves. Juveniles rear in the lake for 1 to 3 years before smolting and migrating to the marine environment for 1 to 4 years; adults generally return to their natal lake system to spawn. Effects to kokanee populations will be discussed in the resident sections where they occur.

Three Sockeye Salmon ESUs are within the scope of this EIS:

- Snake River (ESA-listed, further discussed in this section)

- Okanagan River (not ESA-listed)
- Lake Wenatchee (not ESA-listed)

<u>Snake River Sockeye Salmon</u>

Snake River sockeye salmon are ESA-listed as endangered. This ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River Basin, primarily from Redfish Lake, and also sockeye salmon from an artificial propagation program, Redfish Lake Captive Broodstock Program. Snake River sockeye salmon migrate through eight Columbia River System projects on their migratory route to and from the Pacific Ocean (NMFS 2009).

Adult Snake River sockeye salmon enter the Columbia River primarily from June through July when they migrate directly to suitable lake habitat to spawn. Adult sockeye salmon will spawn from September through October in the lakeshore gravels (ODFW and WDFW 2017). Anadromous juveniles will rear in their natal lakes for one to three years before outmigrating. Anadromous Snake River sockeye salmon juveniles migrate to the ocean from April through early July, with peak migration typically occurring in mid-April to early May (Figure 3-118) (NMFS 2015).

Resident sockeye salmon remain in freshwater to mature and reproduce (often referred to as kokanee).

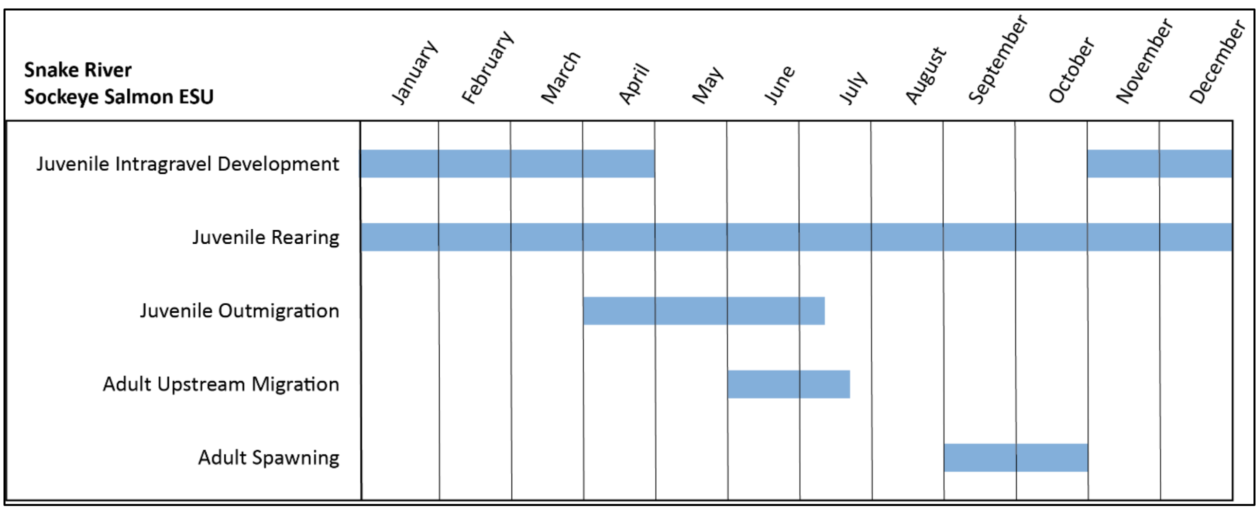



**Figure 3-118. Freshwater Life Phases of Snake River Sockeye Salmon Evolutionarily Significant Unit**

Source: NMFS (2015)

***Coho Salmon***

Coho salmon are also commonly known as silver salmon. Coho are anadromous, with a fixed life history, and semelparous. Coho salmon south of Alaska are three years old at maturity, spending half of that time in the freshwater environment prior to smolting (Weitkamp et al.

1995). Historically, coho salmon distribution extended to the upper Columbia River and the Snake River Basin (Weitkamp et al. 1995).

Lower Columbia River coho salmon are the only ESA-listed population of coho salmon in the Columbia River Basin; coho salmon found upstream of The Dalles Dam are not ESA-listed. Although coho salmon in the upper Columbia River, Snake River and their tributaries were extirpated, reintroduction programs conducted in the Clearwater, Wenatchee, Methow, and Yakima River Basins are resulting in coho salmon returning to those rivers.

<u>Lower Columbia River Coho Salmon</u>

Bonneville Dam is the only mainstem system facility within the lower Columbia River coho salmon ESU range (NMFS 2013). These fish extend up the Columbia River as far as the Hood River basin and may encounter other dams in tributaries to the Columbia River depending on their spawning locations, rearing, and migratory movements within the basin (NMFS 2016a).

Two categories are used regarding lower Columbia River coho salmon based on their return to freshwater: early-return (Type S) and late-return (Type N). While there is some overlap between these populations, Type S coho salmon generally move south of the Columbia River mouth once smolts outmigrate, and Type N coho salmon smolts and adults generally move north of the Columbia River mouth (NMFS 2013).

Type S and Type N coho salmon juveniles rear in freshwater for one to four years in pool habitat and quiet backwaters, side channels, and small creeks. Juveniles typically outmigrate as smolts from April to June, typically during their second year (Figure 3-119) (NMFS 2013). Lower Columbia River coho salmon exhibit a stream-type maturation, indicating they arrive in the Columbia River and require several months within freshwater to reach sexual maturity before spawning. Type S coho salmon adults enter freshwater in mid-August before spawning from mid-October to early November. Type N coho salmon adults enter freshwater from late September to December and spawn nearly immediately from November through January (NMFS 2013).

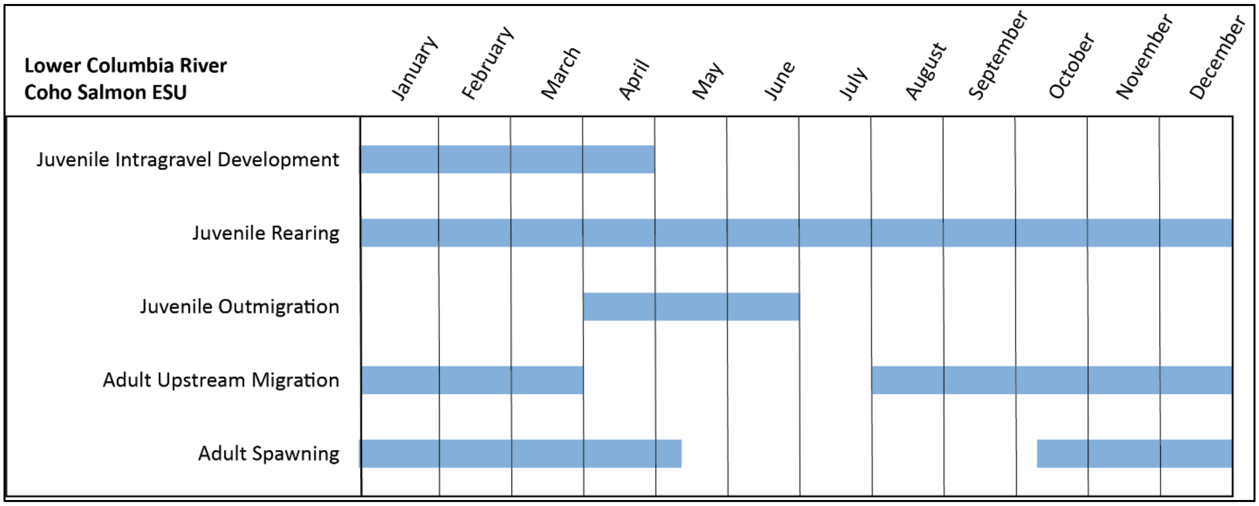



**Figure 3-119. Freshwater Life Phases of Lower Columbia River Coho Salmon Evolutionarily Significant Unit**

Source: NMFS (2013)

***Chum Salmon***

<u>Columbia River Chum Salmon</u>

Although distributed in locations above the dam historically, Bonneville Dam is the only mainstem hydropower facility within the mainstem Columbia River that chum salmon may be expected to pass (NMFS 2013). Though chum salmon are strong swimmers, they rarely pass river blockages and waterfalls, and spawn almost exclusively downstream of Bonneville Dam (NMFS 2016a).

Columbia River chum salmon spawn and incubate redds in the mainstem itself, and spawning is restricted primarily to tributary and mainstem areas downstream of Bonneville Dam. The species requires clean gravel for spawning and their spawning sites are typically associated with areas of upwelling water. Near Ives Island (downstream of Bonneville Dam), chum spawn in shallow areas where it appears river water is warmed by its transit through the gravel (Geist et al. 2002). Chum salmon also spawn in the tailrace of Bonneville Dam.

Columbia River chum salmon juveniles rear in freshwater very briefly after emerging from gravel. Juveniles typically outmigrate to the Columbia River estuary as subyearlings from March to June, where they spend several weeks to months before continuing to the ocean (NMFS 2013) (Figure 3-120). Columbia River chum salmon are primarily fall-run fish with very few exhibiting a summer-run life history. Adults arrive in freshwater from October through November after 2 to 6 years and spawn from November through December (NMFS 2013). During chum salmon spawning and egg incubation, the water surface elevation of the Bonneville tailrace is controlled to protect chum salmon redds (NMFS 2016b).

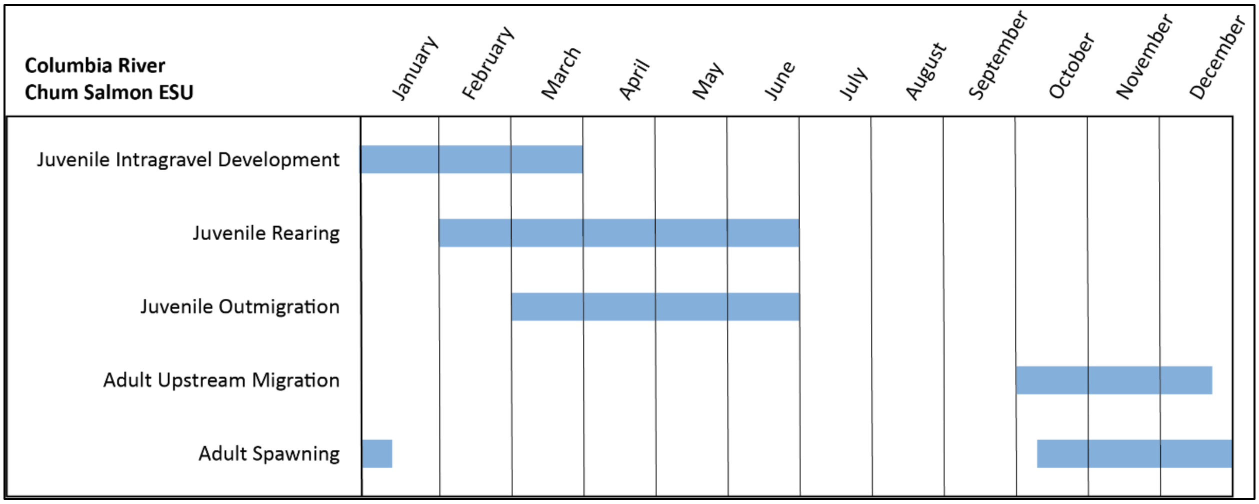



**Figure 3-120. Freshwater Life Phases of Columbia River Chum Salmon Evolutionarily Significant Unit**

Source: NMFS (2013)

### *Steelhead*

The name *steelhead* is used in this EIS to refer to anadromous populations of the biological species *Oncorhynchus mykiss*. Steelhead are anadromous, although individual fish may residualize and remain non-anadromous and have the capacity for iteroparity. Iteroparous steelhead are predominately female (Busby et al. 1996); males tend to be semelparous. Juvenile steelhead can spend between one and seven years in freshwater prior to smolting, and then spend up to three years in the ocean before their first spawning migration (Busby et al. 1996). Most steelhead in the Columbia River Basin spend two years in freshwater and two years in the ocean; some populations east of the Cascade Crest have only one ocean year (Busby et al. 1996). Steelhead have two reproductive ecotypes: ocean-maturing and stream-maturing (Busby et al. 1996). On the West Coast, these correspond to winter steelhead and summer steelhead, respectively. Ocean-maturing winter steelhead enter freshwater in a sexually mature condition and spawn shortly thereafter; stream-maturing summer steelhead enter freshwater in a sexually immature condition and can spend several months in freshwater prior to spawning (Busby et al. 1996). Both of these ecotypes occur in the Columbia River Basin.

Steelhead, and their non-anadromous kin, have two major genetic groupings that are different enough to be considered subspecies by some authors: coastal steelhead and rainbow trout (*O. m. irideus*), and inland steelhead and redband trout (*O. m. gairdneri*). Both subspecies occur in the Columbia River Basin. The coastal grouping occurs as far upstream as the Hood River in Oregon and the Wind River in Washington. The inland grouping occurs upstream of those rivers. Coastal steelhead can be winter or summer steelhead; inland steelhead are almost exclusively summer steelhead (i.e., stream-maturing) (Busby et al. 1996).

After spawning, some adult steelhead (up to 50 percent) do not die and, instead, attempt to return to the ocean, which requires these fish to migrate downstream through the dams as adults. These fish are referred to as kelts and migrate downstream in April and May during the spring freshet, similar to salmon smolts. Adult fish passage through the dams is difficult and dependent on flow, so passage survival is low during low-flow years.

Four steelhead DPSs are within the scope of this EIS:

- Upper Columbia River (ESA-listed threatened, further discussed in this section)
- Middle Columbia River (ESA-listed threatened, further discussed in this section)
- Lower Columbia River (ESA-listed threatened, further discussed in this section)
- Snake River Basin (ESA-listed threatened, further discussed in this section)

**What Are the Terms Used to Describe Steelhead?**

Steelhead are one of three salmonid species in the Columbia River Basin (besides coastal cutthroat trout and bull trout) that may spawn multiple times.

**Overwintering:** Winter runs of steelhead migrate upstream between November and April, and spawn quickly after arrival at spawning grounds. Summer run steelhead migrate from early summer to late fall to use "overwintering" habitat in reservoirs or low in tributaries before spawning in higher elevation habitat months later in early spring.

**Overshoots:** Some migrating adult steelhead may swim past their natal home stream as noted in passive integrated transponder (PIT) tag detections at dams upstream from the known source stream; these steelhead are referred to as "overshoots."

**Kelts:** After spawning, as many as 50 percent of steelhead can live to spawn again. They migrate downstream to marine waters to feed as post-spawn adults. These downstream migrating adult steelhead are called "kelts."

**What is Unique about Steelhead Life History?**

The life history pattern of steelhead in the upper Columbia River Basin is complex. Adults return to the Columbia River in the late summer and early fall. Unlike fall Chinook, most steelhead do not move upstream quickly to tributary spawning streams. A portion of the returning run overwinters in the mainstem reservoirs, passing over the upper Columbia River dams in April and May of the following year. Spawning occurs in late spring of the calendar year following entry into the river. Currently, the majority of adult steelhead passing Lower Granite Dam are hatchery origin fish. The effectiveness of hatchery fish spawning in the wild compared to naturally produced spawners is unknown at this time and may be a major factor in reducing steelhead productivity.

Juvenile steelhead typically spend one to three years rearing in freshwater before migrating to the ocean but can spend as many as seven years in freshwater before migrating. Most adult steelhead return to the upper Columbia River after one or two years at sea. Steelhead in the upper Columbia River have a relatively high fecundity, averaging between 5,300 and 6,000 eggs.

Steelhead can lose the ability to smolt in tributaries and never migrate to sea, thereby becoming resident rainbow trout. Conversely, progeny of resident rainbow trout can migrate to the sea and thereby become steelhead. Despite the apparent reproductive exchange between resident and anadromous *O. mykiss*, the two life forms remain separated physically, physiologically, ecologically, and behaviorally (70 FR 67130). Given this separation, NMFS (70 FR 67130) has proposed that the anadromous steelhead populations are discrete from the resident rainbow trout populations.

### Upper Columbia River Steelhead

Upper Columbia River steelhead may migrate through as many as nine dams including four Columbia River System projects within the Columbia River (Bonneville, The Dalles, John Day, and McNary Dams) on their migratory route to and from the Pacific Ocean, dependent on where the species has spawned (NMFS 2009). Overshoot steelhead may pass through Ice Harbor and Lower Monumental Dams in the Snake River, needing to then pass downstream out of the Snake River to continue their migration up the Columbia River. Chief Joseph Dam has no upstream fish passage and represents the end of the anadromous zone.

Upper Columbia River steelhead juveniles migrate to the ocean from mid-April through early June, with peak migration typically occurring in mid-May (Daly et al. 2014). Juveniles rear in the Columbia River for one to three years before outmigrating (Figure 3-121). Adult upper Columbia River steelhead enter freshwater from late summer to early fall and overwinter in larger rivers, such as the Columbia River, before migrating to tributaries to spawn. Adult steelhead then spawn from the following April through mid-June (NMFS 2007).

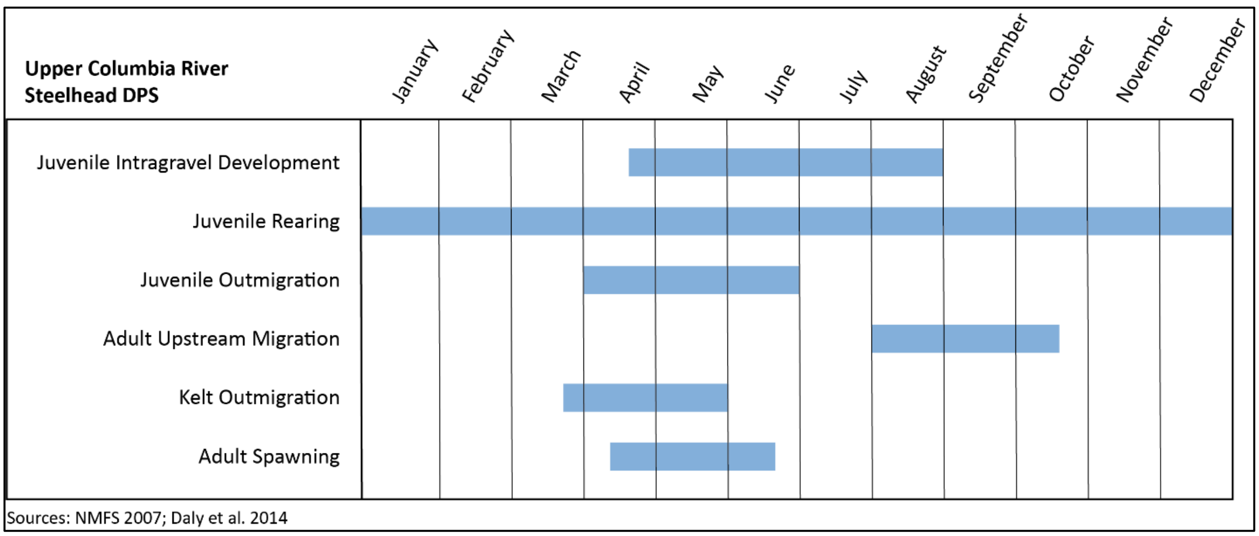



**Figure 3-121. Freshwater Life Phases of Upper Columbia River Steelhead Distinct Population Segment**

Source: NMFS (2007); Daly et al. (2014)

<u>Middle Columbia River Steelhead Distinct Population Segment</u>

Middle Columbia River steelhead may migrate through four projects within the Columbia River (Bonneville, The Dalles, John Day, and McNary Dams) on their migratory route to and from the Pacific Ocean. These fish may pass additional dams outside the project area depending on the population (NMFS 2009).

Two distinct forms are recognized for the Middle Columbia River Steelhead DPS: the stream-maturing type (summer-run steelhead) that require several months in freshwater prior to spawning and the ocean-maturing type (winter-run steelhead) that enter freshwater and spawn shortly after winter entry (Figure 3-122). Most middle Columbia River steelhead are summer-run steelhead (ODFW and WDFW 2017).

Columbia River steelhead juveniles (both summer-run and winter-run) migrate to the ocean from mid-April through early June with peak migration typically occurring in mid-May (Daly et al. 2014). Juvenile winter steelhead outmigrate March through June (ODFW and WDFW 2017). Summer steelhead enter freshwater from April through October and overwinter in larger rivers, such as the Columbia River. Winter steelhead enter freshwater from November to April and migrate to spawning areas immediately. Both summer and winter steelhead spawn from March through June (ODFW and WDFW 2017).

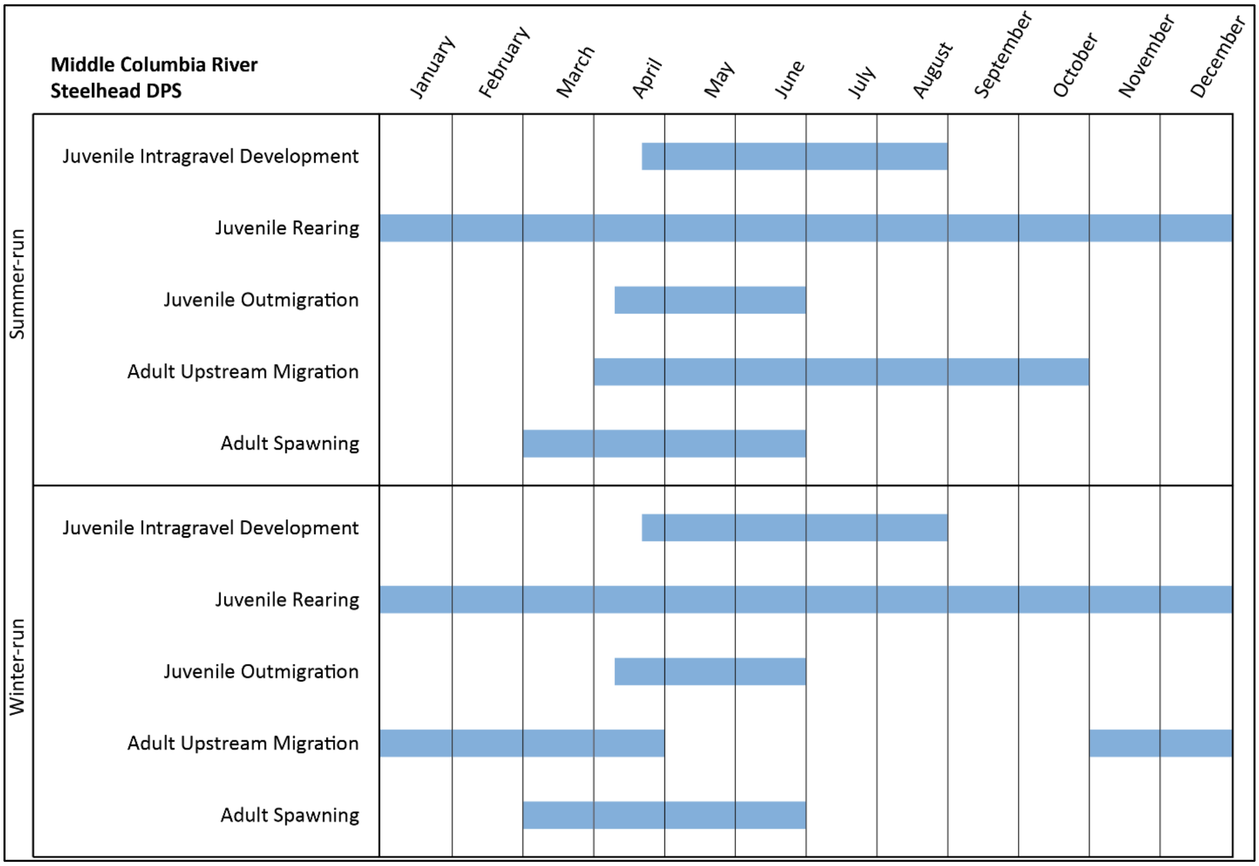



**Figure 3-122. Freshwater Life Phases of Middle Columbia River Steelhead Distinct Population Segment**

Source: ODFW (2010); Daly et al. (2014); DOE (2015); Keefer et al. (2015); ODFW and WDFW (2017)

Lower Columbia River Steelhead Distinct Population Segment

Two distinct forms are recognized for the Lower Columbia River Steelhead population: the summer-run steelhead that require several months in freshwater prior to spawning, and winter-run steelhead that enter freshwater and spawn shortly after winter entry (Figure 3-123). The majority of lower Columbia River steelhead are summer-run steelhead (NMFS 2016). Only Bonneville dam is encountered by this population of steelhead.

Lower Columbia River steelhead summer-run and winter-run juveniles rear for 1 to 4 years before outmigrating as smolts from March to June (NMFS 2013) (Figure 3-124). Adult summer-run steelhead enter freshwater from May to October and require several months to mature prior to spawning from late February to early April. Winter-run steelhead enter freshwater from

December to May already sexually mature and spawn in the spring between April and May (NMFS 2013).

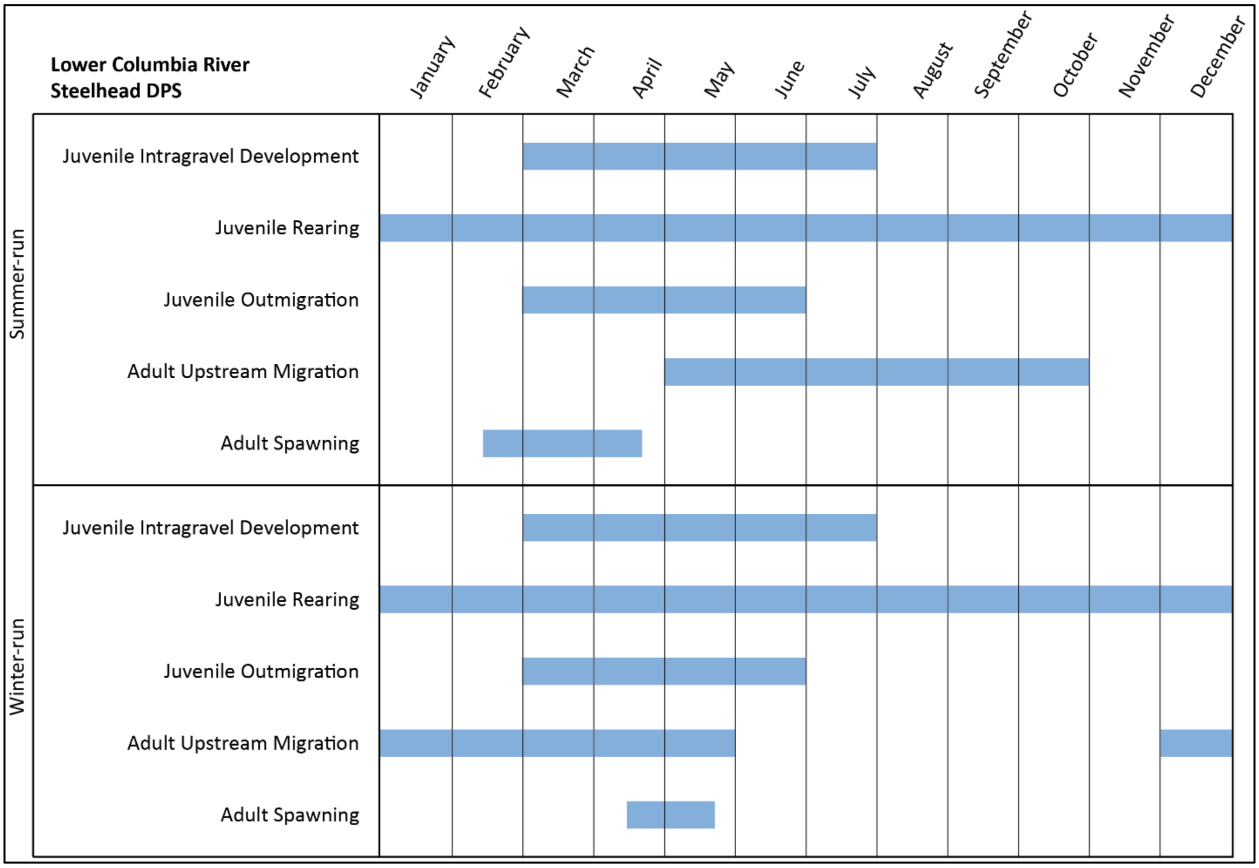



**Figure 3-123. Freshwater Life Phases of Lower Columbia River Steelhead Distinct Population Segment**

Source: NMFS (2013)

<u>Snake River Steelhead</u>

Snake River steelhead may migrate through as many as eight Columbia River System projects within the Columbia and Snake Rivers on their migratory route to and from the Pacific Ocean dependent on where the species has spawned (NMFS 2009). Columbia River System projects that Snake River Basin steelhead migrate through include the four lower Columbia River dams and four lower Snake River dams.

Snake River Basin steelhead juveniles migrate to the ocean from April to June with peak migration typically occurring in mid-May (Figure 3-124) (NMFS 2017). Steelhead have high variability in the duration juveniles rear in their natal streams; typically, juveniles will smolt between 2 and 3 years. Snake River Basin steelhead are primarily considered summer-run as adults enter freshwater from June through August and continue migrating during September before overwintering in the mainstem rivers and tributaries throughout their range. The adults then migrate to tributaries to spawn between March and early June.

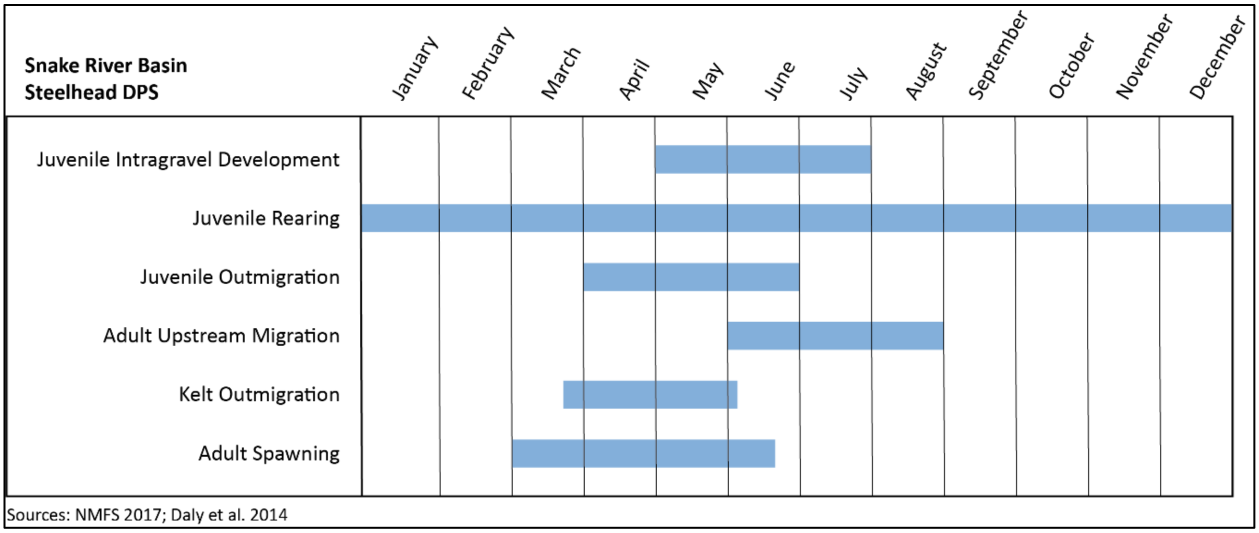



**Figure 3-124. Freshwater Life Phases of Snake River Basin Steelhead Distinct Population Segment**

Source: Daly et al. (2014); NMFS (2017)

### Other Endangered Species Act–Listed Anadromous Fish

Other ESA-listed anadromous fish beyond salmon and steelhead species are also located within the study area.

#### *Eulachon*

Eulachon (*Thaleichthys pacificus*), also known as Pacific smelt, are an anadromous smelt, endemic to the northeastern Pacific Ocean. They spawn in rivers from northern California to southwestern Alaska (NMFS 2017). Eulachon are rich in calories and are important to marine and freshwater food webs, commercial and recreational fishers, and indigenous people (WDFW and ODFW 2001). Eulachon are prey for marine mammals, salmon, sturgeon, and birds. In marine waters, eulachon are important in the food chain as prey of salmon and steelhead (Gustafson et al. 2010). Based on genetic information and spawning site fidelity, NMFS has determined that eulachon along the West Coast contains two DPSs. Only the Southern DPS of eulachon occur in the action area.

<u>Southern Eulachon Distinct Population Segment</u>

The southern eulachon DPS includes fish that spawn in rivers south of the Nass River in British Columbia to, and including the Mad River in California (Gustafson et al. 2010). Tributaries of the Columbia River that have supported eulachon runs in the past include the Grays, Elochoman, Cowlitz, Kalama, and Lewis Rivers in Washington and the Sandy River in Oregon (Gustafson et al. 2010). In the Columbia River, eulachon spawning runs occur annually on the mainstem lower Columbia and Cowlitz Rivers; these areas are downstream from Bonneville Dam, and the historical range included areas just upstream from the dam (Fish Commission of Oregon 1953).

Critical habitat for this DPS was defined on October 20, 2011, and includes the physical and biological features essential for conservation of eulachon in freshwater and estuarine areas downstream of Bonneville Dam (76 FR 65324). As described in its critical habitat designation, important eulachon habitat features can be summarized as (1) freshwater spawning and incubation sites with supportive water flow, quality, and temperature conditions; (2) unobstructed freshwater and estuarine migration corridors; and (3) nearshore and offshore marine foraging habitat with supportive water quality and available prey (76 FR 65324). The largest spawning run of eulachon uses the lower Columbia River mainstem and tributaries.

The timing and usage of spawning habitats has considerable year-to-year variation and is dependent on site-specific environmental factors in the lower Columbia River. Eulachon migration beyond the Lewis River (RM 87) is limited to years of very high abundance and passage to Bonneville Dam (RM 146) is rare (WDFW 2009). Historical investigations from the 1950s indicate adult eulachon occasionally migrated to Bonneville Dam, with some fish successfully passing the dam through the navigation locks to spawn as far upstream as Hood River (Fish Commission of Oregon 1953; Smith and Saalfeld 1955).

Eulachon eggs are released and fertilized in the water column in a broadcast spawning strategy (Cowlitz Indian Tribe 2014). Fertile eggs in the water column slowly sink as they drift downstream and eventually adhere to river substrates, typically in areas of pea-sized gravel and coarse sand (WDFW and ODFW 2001). Fertilized eggs typically require 30 to 40 days for larval development before hatching. After this incubation period, the eggs hatch and the larvae drift immediately out to the estuary, usually within hours to days (Cowlitz Indian Tribe 2014). Because the larvae are rapidly flushed out to the ocean by river currents with minimal time in freshwater, it is believed eulachon imprint and home to their native estuary, then select specific rivers and spawning areas based on environmental conditions at the time of their return (Hay and McCarter 2000). Adult eulachon typically enter the lower Columbia River from December to March (ODFW and WDFW 2001; NMFS 2008). A small run of eulachon can occur as early as mid-November (Cowlitz Indian Tribe 2014). Multiple runs of eulachon may migrate through the river each year. Peak abundance typically occurs in February and March (NMFS 2008). Spawning occurs in the lower sections of rivers at temperatures ranging from 4°C to 10°C. Water temperatures colder than 4°C can slow or stop migration (ODFW and WDFW 2001). When river temperatures vary above or below normal, eulachon may fail to spawn, delay spawning, or modify their migratory behavior (NMFS 2017).

#### *Green Sturgeon*

The green sturgeon (*Acipenser medirostris*) is a marine-oriented and slow-growing anadromous fish (average length of 50 to 55 inches, or 130 cm) that ranges from Alaska to Mexico. Outside of their natal system, adult and subadult green sturgeon migrate to the lower Columbia River estuary for feeding and optimization of growth (NMFS 2009). Within the lower Columbia River Basin, green sturgeon are common and were observed as far as 140 miles (225 km) upstream in the Columbia River prior to the construction of Bonneville Dam (Wydoski and Whitney 1979). Today, they do not move upriver beyond about RM 27 (WDFW 2007). In estuaries, they feed on shrimp, amphipods, isopods, clams, worms, and an assortment of crabs and fish (Moyle et al. 1995; Dumbauld, Holden, and Langness 2008).

Based on genetic information and spawning site fidelity, NMFS has determined green sturgeon along the West Coast contain two DPSs: (1) a northern DPS consisting of populations in coastal watersheds northward and including the Eel River; and (2) a southern DPS consisting of coastal Central Valley populations south of the Eel River, which is its only known spawning population in the Sacramento River (68 FR 4433; NMFS 2002). The northern DPS is not listed. Both the southern and northern DPSs occur in the Columbia River with recent surveys showing more southern DPS than northern DPS green sturgeon (NMFS 2015).

Southern Green Sturgeon Distinct Population Segment

The southern DPS green sturgeon appear in high concentrations in coastal bays and estuaries along the west coast of North America during the summer and autumn, particularly in Willapa Bay, Grays Harbor, and the Columbia River estuary. Recent data indicates the majority of these fish are either immature or in the early stages of maturation (WDFW and ODFW 2012).

Designated green sturgeon critical habitat includes the Columbia River estuary from the mouth to RM 46 (74 FR 52300).

Juvenile green sturgeon are not known to use the lower Columbia River estuary (NMFS 2018). However, in 2011, WDFW and ODFW (2012) found an age-0 (i.e., less than 1 year old) green sturgeon in the Columbia River downstream of Bonneville Dam. This was the first time an age-0 green sturgeon had been observed in the Columbia River. The specimen was retained and preserved, and genetic analysis confirmed that the animal is a green sturgeon (NMFS 2015).

Adult green sturgeon congregate in deep water areas of the estuary during the summer and fall based on tagging and recapture studies and subsequent analyses (ODFW and WDFW 2014). Peak numbers of green sturgeon occur from July through September (WDFW 2007); during this period, the Columbia River estuary is believed to have the largest concentration of southern DPS green sturgeon compared to other estuaries along the West Coast (NMFS 2009). Commercial gillnet harvest records from 1981 to 2003 provide evidence that green sturgeon primarily use the lower portions of the Columbia River estuary, with infrequent movement upstream of RM 27 (WDFW 2007).

**NON-ENDANGERED SPECIES ACT–LISTED ANADROMOUS FISH**

An inventory of the non-ESA-listed anadromous species in the study area appears in Table 3-58.

**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 (*Oncorhynchus tshawytscha*) |
| Middle Columbia Spring Chinook ESU (*O. tshawytscha*) |
| Southwest Washington Steelhead DPS (*O. mykiss*) |
| Upper Columbia River Sockeye ESU (*O. nerka*) |
| Upper Columbia River Coho ESU (*O. kisutch*) |
| Snake River Coho ESU (*O. kisutch*) |
| Pacific lamprey (*Entosphenus tridentatus*) |

### Salmon and Steelhead

#### *Chinook Salmon*

Upper Columbia River Summer/Fall-Run Chinook Salmon

This ESU is not ESA-listed and was considered not warranted for listing (Myers et al. 1998). Hatchery production is associated with this ESU. The EIS focus for this species is where the species occurs and migrates through the mainstem of the Columbia and Snake Rivers.

Upper Columbia River summer/fall-run Chinook salmon may migrate through four Columbia River System projects based on their spawning area location and travel route to the ocean. These projects include the four lower Columbia dams. The species migrates through several other dams in the Columbia River and its tributaries, and the species spawns within the mainstem of the Columbia River and tributaries including the Wenatchee, Entiat, Chelan, Methow, Okanogan, and Similkameen Rivers.

Summer-run and fall-run Columbia River Chinook salmon have an ocean-type or subyearling life history, where young fish emerge from redds from late winter through early spring, rear and grow rapidly, and then migrate seaward before mid-summer (Figure 3-125). In addition, many upper Columbia River hatchery origin summer Chinook display a yearling life history, where they grow more slowly and holdover one year and migrate to the ocean the following year. Summer Chinook salmon enter the Columbia River from late spring (May) through late summer (August), whereas fall Chinook salmon enter the Columbia River from late summer (early August) through early November.

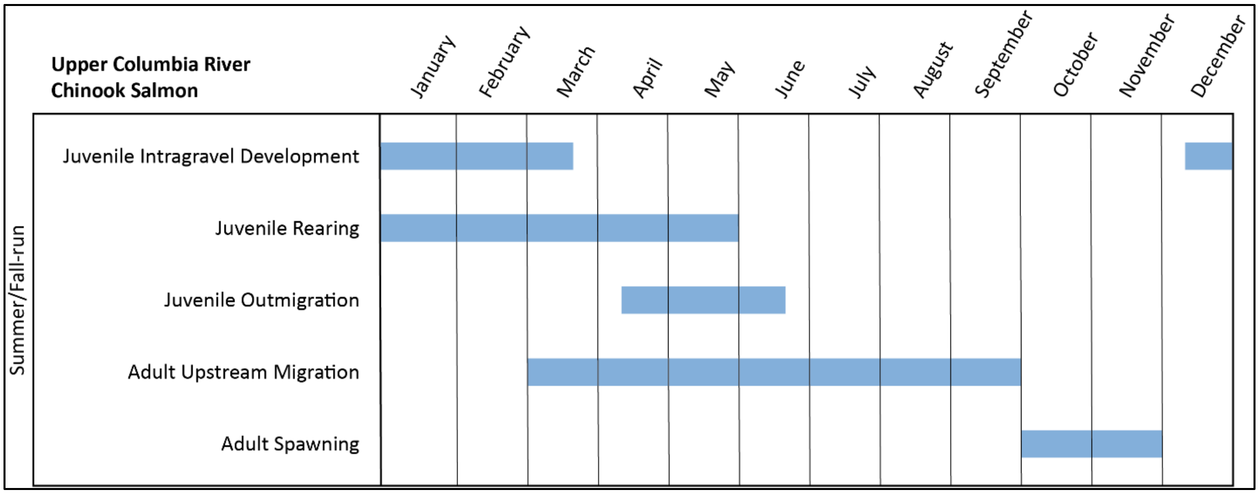



**Figure 3-125. Freshwater Life Phases of Columbia River Summer/Fall-Run Chinook Salmon**

Source: WDFW (2006)

<u>Middle Columbia River Spring-Run Chinook Salmon</u>

This ESU is not ESA-listed and was considered not warranted in 1998 (63 FR 11482). The EIS focus for this species is where the species occurs and migrates through the mainstem of the Columbia River.

Middle Columbia River spring-run Chinook salmon may migrate through four projects within the lower Columbia River on their migratory route to and from the Pacific Ocean dependent on where the species has spawned.

Middle Columbia River spring-run Chinook salmon juveniles have a similar life history as upper Columbia River spring-run Chinook salmon. The fish migrate to the ocean in the spring of their second year of life. Juvenile spring-run Chinook salmon outmigrate after one year of rearing, mid-spring through early summer (Figure 3-126). Similar to upper Columbia River spring-run Chinook salmon, middle Columbia River spring-run Chinook salmon adults enter freshwater from early spring, with the peak run occurring in mid-May, and reach the upper Columbia River tributaries from April through July. Some males return to natal streams after one winter at sea; however, the 4- and 5-year-old adults are the majority of the run. The adults then hold in the tributaries until spawning in the late summer, peaking in mid-late August. Adults die within about 1 week after spawning.

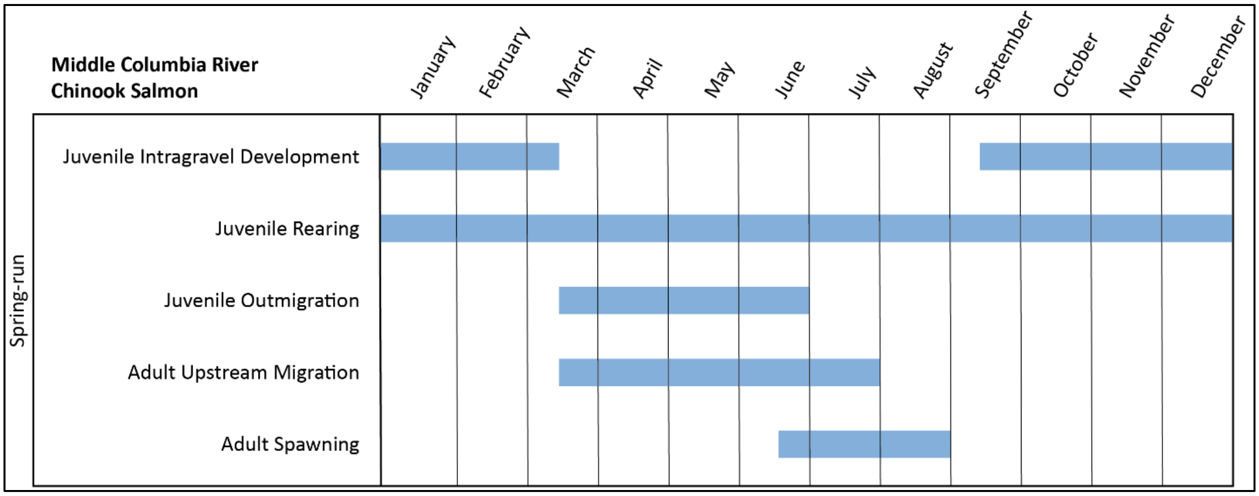



**Figure 3-126. Freshwater Life Phases of Middle Columbia River Spring-Run Chinook Salmon Evolutionarily Significant Unit**

Source: NMFS (2007, 2018)

### *Sockeye Salmon*

Upper Columbia River Sockeye Salmon

Upper Columbia River sockeye salmon are not ESA-listed. Currently, Lake Wenatchee, in the Wenatchee Basin, and Lake Osoyoos, in the Okanogan Basin, are the two main sockeye salmon–producing lakes in the Columbia River Basin; officially they constitute separate ESUs: the Lake Wenatchee Sockeye Salmon ESU and the Okanogan River Sockeye Salmon ESU. Upper Columbia River sockeye salmon migrate through as many as nine dams on their migratory route to and from the Pacific Ocean; four CRS projects and up to five PUD owned mainstem dams (Wells Dam is owned and operated by Douglas County PUD; Rocky Reach Dam and Rock Island Dam which are owned and operated by Chelan County PUD; and Wanapum Dam and Priest Rapids Dam which are owned and operated by Grant County PUD).

Anadromous juveniles will rear in their natal lakes for one to three years before outmigrating. Anadromous Upper Columbia River sockeye salmon juveniles migrate to the ocean from April through early July, with peak migration typically occurring in mid-April to early May. Adult sockeye salmon will spawn from September through October in the lakeshore gravels.

Okanogan sockeye salmon are currently the most abundant sockeye salmon stock in the Columbia River Basin. Most Okanogan sockeye salmon rear in Osoyoos Lake, which spans the U.S.-Canada border. Production of Okanogan sockeye salmon occurs largely in British Columbia.

The majority of Wenatchee sockeye spawn in the White River and Little Wenatchee River, with some spawning also occurring in the Napeequa River (WDFW 2020). These fish rear in Lake Wenatchee, a natural lake on the Wenatchee River in Washington State before outmigrating to the ocean.

### *Coho Salmon*

Upper Columbia River Coho Evolutionarily Significant Unit

Upper Columbia River Coho are not-ESA listed.

Upper Columbia River coho pass the four lower Columbia River dams. While originally these fish were sourced from hatchery coho programs, there are hatchery releases and natural spawning now occurs in the Yakima, Wenatchee, Entiat, and Methow basins.

While the coho salmon hatchery production above Bonneville Dam does not affect a defined ESU or ESUs of coho salmon, it contributes to the rebuilding natural coho salmon populations (listed and unlisted), as well as benefits and risks to other salmon ESUs and steelhead DPSs. These programs can provide benefits to the abundance, productivity, and spatial structure of coho salmon, as well as provide benefits to other species of salmon and steelheads through marine-derived nutrients from the adult carcasses, cleaning and transport of spawning gravels, and as a prey base for other salmon and steelheads. However, they also present risks to these other species in the form of ecological interactions, including competition for scarce resources and direct and/or indirect predation. Additionally, the hatchery facilities where these programs are reared and released pose risks associated with delaying or blocking migration of adult and juvenile fish, as well as risks from water withdrawal and effluent discharge.

Snake River Coho Evolutionarily Significant Unit

Snake River Coho are not ESA-listed.

Snake River coho pass the four lower Snake dams as well as the four lower Columbia River dams. While originally these fish were sourced from hatchery coho programs, there is natural spawning that occurs now in the Snake basin tributaries.

While the coho salmon hatchery production above Bonneville Dam does not affect a defined ESU or ESUs of coho salmon, it contributes to the rebuilding natural coho salmon populations (listed and unlisted), as well as benefits and risks to other salmon ESUs and steelhead DPSs. These programs can provide benefits to the abundance, productivity, and spatial structure of coho salmon, as well as provide benefits to other species of salmon and steelheads through marine-derived nutrients from the adult carcasses, cleaning and transport of spawning gravels, and as a prey base for other salmon and steelheads. However, they also present risks to these other species in the form of ecological interactions, including competition for scarce resources and direct and/or indirect predation. Additionally, the hatchery facilities where these programs are reared and released pose risks associated with delaying or blocking migration of adult and juvenile fish, as well as risks from water withdrawal and effluent discharge.

### Other Non-Endangered Species Act–Listed Anadromous Fish

#### *Pacific Lamprey*

The Pacific lamprey (*Entosphenus tridentatus*), an anadromous species that is parasitic during its ocean phase. It is the most widely distributed lamprey species on the West Coast (Meeuwig et al. 2004). Pacific lamprey occur within the Columbia and Snake Rivers. It was estimated that the population of lampreys in the 1960s and 1970s may have been as many as 1 million adults at Bonneville Dam (Columbia River Inter-Tribal Fish Commission [CRITFC] 2011). However, due to several factors, including impediments to passage, Pacific lamprey abundance declined significantly in the Columbia River Basin to near extirpation in some tributaries (CRITFC 2011a). The Pacific lamprey is not a federal ESA-listed species, but it is a threatened species by the State of Idaho (IDAPA 13.01.06). Pacific lamprey were listed as an Oregon State sensitive species in 1993. In December 2004, the USFWS ruled there was not substantial scientific or commercial information to warrant a Federal listing of Pacific lamprey (69 FR 77158).

Pacific lamprey may migrate through as many as eight Columbia River System projects within the Columbia and Snake Rivers along their migratory route to and from the Pacific Ocean. Individual Pacific lamprey have been detected as far upstream as the Salmon River subbasin. However, Pacific lamprey do not necessarily return to natal locations, but often return to other river systems in the Pacific Northwest. Lamprey occupancy is constrained to below dams that lack fish passage on the Columbia and Snake Rivers (Moser and Close 2003).

All lamprey begin life in freshwater and share similar characteristics as ammocoetes (i.e., larvae), but they exhibit different life histories as they develop. Time to hatch varies based on water temperature, which is an important factor for lamprey embryonic and larval development. Effects of temperature on larval hatching and development were examined and an increase in abnormalities occurred at a temperature of 22°C, while zero development occurred at 4.85°C. The optimal temperature for this study was found to be 18°C (Meeuwig et al. 2005). After emerging, larvae will eventually drift downstream to locations of low velocity and fine silt and begin the burrowing phase (Brumo 2006).

Larval lamprey phase is strongly associated with stream and river sediments. Larvae burrow in sediments for 3 to 7 years after hatching, where they filter feed on detritus and organic material. Larval lamprey prefer areas with accumulated deep, fine substrates (McIlraith et al. 2017). Lamprey may spend up to 10 years as larvae prior to transformation to juvenile phase (called macrophthalmia) and outmigration. Thus, the availability of suitable habitat for larvae is critical to conservation. The effects of contaminants in sediments on Pacific lamprey larvae may impact survival; bioaccumulation of contaminants is occurring in the larval life stage (Nilsen et al. 2015). They gradually migrate downstream, moving primarily at night, seeking coarser sand/silt substrates and deeper water as they continue to grow and enter their next life stage. The Bonneville and The Dalles pools provide habitat and rearing areas for larval Pacific lamprey, with evidence being that lamprey were detected at river mouths in these pools, as well as in the shallow water pool margins in the Bonneville pool (Jolley et al. 2014). The river mouths provide an important habitat for Pacific lamprey larvae, but they are at risk in this environment because of the potential for stranding (Jolley et al. 2014). Notably, breaching Condit Dam provided habitat for lamprey in the Bonneville Reservoir at the mouth of the White Salmon River (Jolley et al. 2014).

Metamorphosis for juveniles occurs from July to December as they develop eyes, teeth, and become free swimming (Jolley, Silver, and Whitesel 2012). As juveniles mature into adults, they begin their migration to saltwater (69 FR 77158). Outmigrant collections at Bonneville Dam indicate a large winter (January to March) peak, with a slightly smaller peak in June. Far fewer metamorphosed lamprey are seen in July and August (McIlraith et al. 2017).

After spending one to three years in the ocean, Pacific lamprey return to freshwater between February and June (69 FR 77158). Upstream migration by adult lamprey may be influenced by an unknown combination of temperature, discharge, and chemical cues. Adults spend multiple months in the estuary before moving into freshwater habitats. Adult passage at Bonneville Dam for Pacific lamprey typically occurs between May and late August, peaking in July. Most Pacific lamprey take about 2 months to migrate upstream through the Columbia River System projects (McIlraith et al. 2017). Radio telemetry and PIT tag studies have found there is substantial attrition of fish between mainstem dams during the upstream adult migration in the Columbia River (Moser and Close 2003; Keefer et al. 2009). The ability to pass multiple dams to reach spawning locations in the upper reaches of the Columbia and Snake River Basins may be dependent on a variety of factors, including body size, migration timing, and genetic variation (Keefer et al. 2009; Hess et al. 2014).

Pacific lamprey are thought to overwinter and remain in freshwater for approximately 1 year before spawning (69 FR 77158). Adult Pacific lamprey overwinter in locations typically consisting of deep pools with rock cover (McIlraith et al. 2017). Spawning occurs over many days in gravel-bottomed streams at the upstream end of riffle habitat (69 FR 77158).

#### *American Shad*

American shad (shad; *Alosa sapidissima*) is a non-native fish that was introduced to the Pacific Northwest from eastern North America in the 1880s (Fuller and Neilson 2018a). Shad is an anadromous member of the Clupeidae family, which includes herring and sardine (Fuller and Neilson 2018a). Shad can reach 29 inches long and 12 pounds with a maximum life span of 13 years (Froese and Pauly 2018). Adult and juvenile shad feed on zooplankton and fish eggs. This species is not federally or state listed.

Shad are now distributed throughout the mainstem Columbia, Snake, and Willamette Rivers, but they have not been recorded in all tributaries of these rivers. The Columbia River supports the largest population of shad in the world (Sanderson, Barnas, and Rub 2009; Hinrichsen et al. 2013; Froese and Pauly 2018).

Shad migration and juvenile survival varies with water temperature and river discharge; once water temperatures reach 16°C, returning adults spawn between June and August in shallow water over sand or gravel (Hinrichsen et al. 2013). Shad require a temperature range of 13°C to

26°C for eggs and juveniles to successfully grow (Hinrichsen et al. 2013). Hinrichsen et al. (2013) found that lower dam discharges allowed more adult shad to migrate farther upstream due to slower water, which requires less energy to swim through. Juveniles use all portions of rivers; however, they are more abundant in off-channels with dense aquatic vegetation.

Juvenile shad outmigrate to the ocean in the fall when they are between 1 to 4 inches (2.5 to 10.2 cm) long (Lower Columbia Fish Recovery Board 2004c) and return as 3- to 4-year-old adults. A portion of the adult shad return to sea after spawning (Lower Columbia Fish Recovery Board 2004c).

Shad are considered competitors with native fish particularly because both adult and juvenile shad feed on zooplankton that native fish would otherwise consume (Lower Columbia Fish Recovery Board 2004c; Haskell, Tiffan, and Rondorf 2013). The large population of shad within the Columbia and Snake Rivers consume as much as 30 percent of the zooplankton present in these rivers (Haskell, Tiffan, and Rondorf 2013). The large number of juvenile shad present in the river basin may subsidize the diets of non-native fish such as bass, catfish, and walleye that feed on fish, including native fish (Harvey and Kareiva 2005; Sanderson, Barnas, and Rub 2009), thereby contributing to an increasing number of non-native aquatic predators. Juvenile shad may compete with juvenile salmon and steelhead for backwater habitat (Lower Columbia Fish Recovery Board 2004c).

Migrating adult shad may occupy fish ladders during periods when adult salmon and steelhead are migrating upstream (Lower Columbia Fish Recovery Board 2004c; Hinrichsen et al. 2013); raising flows at The Dalles' east fish ladder appears to effectively accommodate adult salmon to avoid overcrowding with adult shad.

ODFW and WDFW promote American shad as a recreational fishing opportunity (ODFW 2018a; WDFW 2018), as well as a managed commercial shad fishery (Lower Columbia Fish Recovery Board 2004c). However, the commercial fishery is limited because adult shad migration overlaps with adult salmon and steelhead migration (Lower Columbia Fish Recovery Board 2004c). No efforts are underway to eradicate shad in the Columbia River Basin.

It is important to note that shad are generalists that tolerate a wide range of conditions and CRS projects are not likely to change the population numbers but could influence their migrations and distributions that affect interactions with native fish.

#### *3.5.2.4 Resident Fish*

As described in Section 3.2.1.1, resident fish are fish that spend their entire lives in freshwater; they are either fluvial (using only rivers for spawning and rearing) or adfluvial (using lakes for feeding and rivers for spawning), or they may simply live in one habitat type, such as a lake or river, their entire life cycle. The kinds and numbers of resident fish vary considerably across the basin. Many species interact with each other and their habitats to form local/regional fish communities. Some of these species are important for recreational, cultural, and commercial harvest. Approximately two-thirds of the fish species in the Columbia River Basin are non-native and the extent of their influence and impacts to native fish assemblages is not well understood (Independent Scientific Advisory Board [ISAB] 2008).

In this section, key fish species in the study area will be discussed, including life history, status, and a general description of their interaction with Columbia River System projects. Then, because (1) effects to resident fish are most effectively evaluated by regions or communities; (2) they are managed on a more localized scale than anadromous fish; and (3) effects from projects tend to vary widely across the Columbia River Basin. The resident fish residing within the Columbia River Basin are generally described, followed by a description of the regional resident fish communities in which they reside. Additionally, the species that are ESA-listed (bull trout and Kootenai River white sturgeon) are discussed in their own sections within each region.

#### ENDANGERED SPECIES ACT–LISTED RESIDENT FISH

An inventory of the ESA-listed resident species and their designated critical habitat in the study area appears in Table 3-59. Details on distribution, population status, and threats to each of these species appear in the *Federal Register* notices that NMFS and the USFWS provide for all listing actions; these are cited in the table. Species status and relevant CRSO study area information appear in their respective subsections later in this section.

**Table 3-59. Status and Critical Habitat of Resident Columbia River Basin Endangered Species Act–Listed Species**

| Species and ESU or DPS | ESA-Listing Status | Critical Habitat Designation |
|---|---|---|
| Bull Trout Columbia River DPS (*Salvelinus confluentus*)[1/, 2/, 3/] | Threatened 1999 | 2004 |
| Kootenai River White Sturgeon (*Acipenser transmontanus*)[1/, 2/] | Endangered 1994 | 2008 |

1/ State-listed threatened: Idaho (IDAPA 13.01.06).
2/ State-listed species of concern: Montana (MFWP 2018).
3/ State Species of Concern: Washington (WDFW)

#### Bull Trout

Bull trout (*Salvelinus confluentus*) are members of the char genus and require very cold, clear water. Smaller juveniles eat terrestrial and aquatic insects; as they grow, they shift to eating fish, with a preference for whitefish, sculpins, and other trout as well as anadromous fish eggs, alevin, fry, smolts, and carcasses (USFWS 1997). Bull trout exhibit multiple life history patterns involving movements and migrations that reflect a high degree of local site fidelity (USFWS 2008b). Bull trout in the Columbia River Basin can be resident or migratory. Resident bull trout spend their entire lives in the same stream, while migratory bull trout spend most of their time in lakes, reservoirs (adfluvial), or large rivers (fluvial). Adult bull trout migrate upstream to spawn in the fall in streams with cold, clear water, and eggs hatch in late winter or early spring. Juveniles rear in the spawning tributaries for 1 to 4 years, and then in migratory life history patterns, juveniles move back downstream to larger rivers or lakes. Bull trout will repeat spawn from sexual maturity of 4 to 7 years throughout their life span, which can reach 12 years.

The bull trout was ESA-listed as threatened in 1999 (64 FR 58910), which was reaffirmed in 2008 in its status review (USFWS 2008b), with critical habitat identified in 2004 (70 FR 63898) and updated in 2010 (75 FR 6398). The recovery plan developed in 2015 outlined reasonable actions to recover and protect bull trout (USFWS 2015b). Bull trout occur throughout the Columbia and Snake River Basins in Washington, Oregon, Idaho, and Montana (USFWS 2015). Bull trout critical habitat, which describes specific locations and elements of the environment essential for the conservation and recovery of the species, was designated for the entire mainstem Columbia River upstream to Chief Joseph Dam and mainstem Snake River upstream to Brownlee Dam, as well as upper tributaries of both rivers (USFWS 2015).

The USFWS status review (2008b) reported bull trout were generally stable range-wide, with some core area populations decreasing, some stable, and some increasing. Since the listing of bull trout as threatened in 1999, there has been little change in the distribution of bull trout in the coterminous United States, with the exception of successful reintroduction into the Clackamas River, and occupied bull trout core areas have not been extirpated since the species listing (USFWS 2015).

In the study area, bull trout occur in substantial populations in the headwater regions, including the Flathead, Clark Fork, Pend Oreille, and Kootenai River Basins. In the Columbia River, bull trout occasionally appear in the upper river from the U.S.-Canada border to Grand Coulee Dam, and the mainstem provides feeding, migration, and overwintering habitat for populations in the Wenatchee, Methow, and Entiat populations (USFWS 2015) between Chief Joseph Dam and McNary Dam. The Snake, Salmon, and Clearwater Rivers provide feeding, migration, and overwintering habitat as well as migration connections for several populations of bull trout. Below McNary Dam, very few bull trout have been observed in the mainstem (Fish Passage Center 2018a, 2018b).

**Kootenai River White Sturgeon**

The Kootenai River white sturgeon (*Acipenser transmontanus*) is a land-locked population of white sturgeon confined to just 168 river miles in Montana and Idaho in the United States and in British Columbia, Canada. Kootenai River white sturgeon are large, long-lived fish with a prehistoric appearance due to rows of bony plates called scutes on their sides. The maximum observed size of Kootenai River white sturgeon based on growth data is about 9 feet, and they could theoretically reach almost 11 feet (Paragamian, Beamesderfer, and Ireland 2005). White sturgeon have sensitive, whisker-like barbels on their snouts that help them detect prey with their downward facing mouth on the riverbed (Scott and Crossman 1973). Kootenai River white sturgeon are opportunistic feeders that prey on a variety of organisms available to them; juveniles prefer small organisms in the substrate such as invertebrates and insect larvae, then as adults their diet shifts mainly to fish with some clams, snails, and aquatic insects (USFWS 1999). Kootenai River white sturgeon were harvested for food, caviar, and for sport until a decline in catch and subsequent harvest restrictions limited the number of white sturgeon taken (Scott and Crossman 1973).

The population ranges from Kootenai Falls (approximately 31 RM downstream of Libby Dam) to Corra Linn Dam at the outlet of Kootenay Lake. Since the last ice age, Kootenai River white sturgeon have been isolated from other downstream white sturgeon populations in the Columbia River Basin by a natural barrier at Bonnington Falls, downstream from Kootenay Lake (USFWS 1999).

The Kootenai River population of white sturgeon was ESA-listed as endangered on September 6, 1994. It is listed as a Montana Species of Special Concern (MFWP 2018) and an Idaho endangered species (IDAPA 13.01.106). Critical habitat for this species was established in 2001, and then expanded in 2008 to include 18.3 river miles of the Kootenai River within Boundary County, Idaho. In January 2018, the USFWS initiated a 5-year status review (83 FR 3104), and a revised recovery plan was completed in September 2019 (USFWS 2019).

The Libby Project is the only Columbia River System project that interacts with Kootenai River white sturgeon. Since its completion in 1974, the Libby Project has greatly changed flow regimes of the Kootenai River compared to flow regimes prior to dam construction. The operation of the Libby Project has reduced peak flow magnitude, changed the timing (seasonality) of the hydrograph, and retained upstream sediment supply. Kootenai River temperature and nutrient regimes, which support primary productivity of the food web, have also been modified (USFWS 1999).

## NON-ENDANGERED SPECIES ACT–LISTED RESIDENT FISH

This section includes a review of Columbia River Basin fish species that are not ESA-listed. Some species that may have a state-listing status or have been identified as a species of interest by the public during scoping, are considered key species and discussed specifically in detail. These key species are categorized as either native or non-native. Other species are described as groups or communities of fish.

### Key Native Fish Species

#### *White Sturgeon (Columbia River)*

White sturgeon are large, long-lived fish with a prehistoric appearance due to rows of bony plates called scutes along their bodies. They are considered the largest freshwater fish in North America and are an important cultural, recreational, and commercial resource in the Columbia River Basin. Unlike the Kootenai River population of white sturgeon, white sturgeon in the Columbia River are not ESA-listed. They occasionally appear in marine waters and typically live in the Columbia River from the mouth to the upper Columbia River in Canada, as well as the Snake River up to Shoshone Falls. They use the Willamette River up to and above Willamette Falls and other lower Columbia River tributaries (Hanson et al. 1992). Adults are opportunistic, bottom-oriented feeders and primarily eat invertebrates and fish. They have unique adaptations for bottom feeding that include ventral barbels and a protrusible mouth.

White sturgeon reach sexual maturity when they are older and larger compared to most fish species found in freshwater, with males maturing at 12 to 25 years of age and females at 15 to 30 years (Bajkov 1949; Scott and Crossman 1973; Galbreath 1985; Hanson et al. 1992; Welch and Beamesderfer 1993; IPC 2005). Reproductive frequency also varies between sexes; males can reproduce every 2 to 4 years, while females were thought to reproduce no more frequently than every 5 years (Conte et al. 1988; Chapman, VanEenennaam, and Doroshov 1996; Anders et al. 2002), though more recent information suggests females can spawn more frequently than every four years. Spawning occurs between April and July during the highest spring flows and when temperatures reach 12°C to 14°C (Hanson et al. 1992; Parsley et al. 1993; Parsley and Beckman 1994). They are broadcast spawners, which means females typically release eggs that are fertilized when males release milt (i.e., sperm) over them. Eggs adhere to river substrate and hatch after 8 to 15 days, depending on water temperature (Brannon et al. 1985). High water velocity is key to spawning site selection (NW Council 2013), and sufficient flows during key spawning times are important. Hatched embryos are called yolk-sac larvae; they have a yolk sac that provides sustenance as the larvae hide among the substrate and seek protection from predators. Small spaces in the substrate are important for this life stage. Once the yolk sac is absorbed, they begin a downstream dispersal and transition to external foods, primarily benthic macroinvertebrates, for the next developmental stage (Brannon et al. 1984; Buddington and Christofferson 1985; Muir et al. 2000; Hildebrand et al. 2016).

Growth during larval stage is dependent on temperature, food availability, location, and genetic variability (CRWSPF 2013; Golder 2003a, 2005a, 2006a, 2000b), with optimal temperatures at 14°C to 17°C. Sturgeon at this stage prefer the deeper, slower velocity areas (McCabe and Hinton 1991; Miller et al. 1991; Parsley et al. 1992) and depend on the currents to transport them into the rearing areas. For white sturgeon, the larval stage ends once the fish has grown enough to complete development of their fins and scutes. White sturgeon recruitment success through this life stage is correlated with sufficient flows during the spawning to larval growth timeframe. This is considered the juvenile stage, and juvenile sturgeon look like a miniature version of adult sturgeon. Juveniles are most often captured within the thalweg (i.e., deepest portion of the river) and rarely adjacent to the thalweg in shallower water (Parsley et al. 1992). Juveniles transition to a sub-adult life stage where they are not yet sexually mature but can fully access marine environments, and then finally considered adults at the onset of sexual maturity.

Adult sturgeon have a tendency to remain in localized areas for extended periods (Golder Associates Ltd. 2010a; Nelson and McAdam 2012; Nelson et al. 2013a, 2013b; BC Hydro 2016a) and show repeated movements between specific locations (Parsley et al. 2008; Golder Associates Ltd. 2010a; Robichaud 2012; Nelson et al. 2013a). Large-scale movements within basins are usually associated with specific life functions such as feeding, spawning, and overwintering (Apperson and Anders 1990; Brannon and Setter 1992).

While the Columbia River downstream of Bonneville Dam supports a wild and self-sustaining white sturgeon population segment, abundance elsewhere in the Columbia River Basin is limited. The population structure of white sturgeon in the Columbia River Basin has been greatly altered by overfishing and extensive dam construction. The construction of dams has substantially modified sturgeon habitat by reducing quality, suitability, and connectivity (Hildebrand et al. 2016). White sturgeon population segments that reside in reservoirs are cut off from the estuary and ocean by hydroelectric development. These populations are recruitment limited and, in general, less abundant when compared to white sturgeon below Bonneville Dam. Based on marking studies and dam counts, white sturgeon do not typically move freely between impoundments.

***Burbot***

Burbot (*Lota lota*) is the only freshwater member of the cod family. They are a native predatory fish that is well suited to deep water habitats of large, cold rivers and reservoirs. Burbot primarily feed at night and are voracious predators, but opportunistic feeders. They are unique in that they spawn during the winter, over fine gravel, sand, or silt, and sometimes under the ice. In rivers, burbot spawn in low velocity areas in main channels or inside channels behind deposition bars. The semi-buoyant eggs are broadcast over the substrate and may drift, but eventually settle into the substrate. Burbot free embryos or yolk-sac larvae remain on the substrate until they have nearly exhausted their yolk reserves, at which point they enter the water column and become pelagic. Burbot fry feed on zooplankton and small aquatic macroinvertebrates, and as they grow, their diet shifts to include fish.

In the CRSO area, burbot are found in the Kootenai River in northern Idaho and Montana, and in the Columbia River in Washington primarily above Chief Joseph Dam in Rufus Woods Lake and Lake Roosevelt upstream to the U.S.-Canada border. Thanks to intensive restoration efforts by the Kootenai Tribe of Idaho, Idaho Fish and Game (IDFG), and fishery professionals from British Columbia, and Montana, a harvest fishery for Burbot was opened in the Kootenai River basin in Idaho on January 1, 2019. The fishery had been closed since 1992 in response to drastic declines in Burbot abundance. The decision to open the fishery hinged on the empirically derived estimate that restoration targets for the number of adult Burbot in the river (i.e., 17,500 spawning adults) was met in 2019. Furthermore, with continued growth and success of the restoration program, it is estimated that the adult population will further grow in abundance, exceeding original restoration targets in coming years. It is listed as a State of Idaho endangered species (IDAPA 13.01.06) and is considered a species of concern in the State of Montana. Operated by the Kootenai Tribe of Idaho, the Twin Rivers Hatchery opened in 2014 at the confluence of the Moyie and Kootenai Rivers in Idaho to help produce burbot for stocking the Kootenai River in multiple locations in British Columbia, Idaho, and Montana.

Burbot abundance can actually increase following impoundment of reservoirs because of increased larval survival and adult foraging opportunities (Bonar et al. 2000) but can decline downstream of dams. As winter spawners, reservoir burbot populations can be sensitive to drawdowns in winter and early spring.

***Columbia River Redband Rainbow Trout***

Columbia River redband rainbow trout (also known as inland redband trout [*Oncorhynchus mykiss gairdneri*]) are a native subspecies of *O. mykiss*, the same species as steelhead and rainbow trout. Therefore, they can have the same diverse life histories; populations may have individuals that exhibit anadromous, adfluvial, fluvial, and resident behaviors (Interior Redband Conservation Team 2016). Researchers have documented the demographics and reproductive characteristics of both and resident histories for Columbia River redband trout populations (Holecek et al. 2012). Columbia River redband trout are typically a stream-resident fish that have short migration either within the same stream or often into smaller tributaries. In areas not blocked by unpassable barriers, the resident and anadromous life history forms of redband trout and steelhead occur together and are known to interbreed. The species spawns in gravel-bottomed, fast-flowing, well-oxygenated rivers and streams. The maximum life span is typically 6 years, and the average length is 12 to 16 inches (30 to 41 cm). Redband trout feed on aquatic insect larvae, crayfish, zooplankton, fish eggs, and some terrestrial insects that drop into the water (Behnke 1992).

Columbia River redband trout occur in the interior Columbia River Basin from east of the Cascades upstream to geologic barriers such as Shoshone Falls on the Snake River (Behnke 2002). Redband occur above Kootenai Falls in Montana and naturally reproducing, genetically pure populations still exist in the Kootenai River downstream of Libby Dam in Callahan Creek, East Fork Yaak River, and tributaries of the Fisher River. Lake Roosevelt and tributaries to the Columbia River that flow into the lake support numerous populations of Redband trout with diverse life history strategies. Redband trout are the most widely distributed native salmonid in the Columbia River Basin (Thurow et al. 2007). They are likely to encounter dams in the interior Columbia River Basin; in some areas, populations have become isolated and have developed alternative life history strategies (e.g., rearing in reservoirs instead of in a stream or river) (Thurow et al. 2007; Holecek and Scarnecchia 2013).

#### *Westslope Cutthroat Trout*

Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*) are native trout that are a genetically distinct subspecies of *O. clarki.* They exhibit multiple life history forms, including adfluvial, fluvial, and resident. They typically spawn in tributary streams in spring when water temperature is about 10°C and flows are high with spring run-off (Committee on the Status of Endangered Wildlife in Canada 2016a). Westslope cutthroat trout have specific habitat requirements during various life history stages necessary to maintain populations. These requirements include cold, clean, well-oxygenated water; clean, well-sorted gravels with minimal fine sediments for successful spawning; temperatures below 21°C; and a complex instream habitat structure such as undercut banks, pool-riffle habitat, and riparian vegetation (Committee on the Status of Endangered Wildlife in Canada 2016a). The average length of westslope cutthroat trout is 8 to 12 inches (20 to 30 cm). They mature within 4 to 6 years and may live as long as 12 years. Westslope cutthroat trout spawn between March and July. Their diet is primarily aquatic invertebrates, with larger trout occasionally preying on other fish (Committee on the Status of Endangered Wildlife in Canada 2016a). The species can produce offspring with non-native rainbow trout or their hybrid progeny and descendants (USFWS 2003).

Westslope cutthroat trout occur in the upper Kootenai River and the Clearwater and Salmon River Basins (McIntyre and Reiman 1995). They were common upstream of Libby Dam after impoundment, but are now uncommon because of dam operation, adverse interactions with non-native fish species, and habitat modifications. Flow fluctuations or low nutrient levels have impacted aquatic insects, a key prey item, in the Kootenai River (Corps 2006). Lake Roosevelt and its tributaries support fluvial, fluvial-adfluvial, and lacustrine-adfluvial life history types.

#### *Northern Pikeminnow*

Northern pikeminnow (pikeminnow; *Ptychocheilus oregonensis*) is a native, resident, freshwater fish that occurs throughout the Pacific Northwest, United States, and British Columbia, Canada (Gadomski et al. 2001; Froese and Pauly 2018). Northern pikeminnow is a member of the Cyprinidae family, which includes minnows and carps (Gadomski et al. 2001; Froese and Pauly 2018). This fish species prefers slow water in lakes and rivers. In as little as three years, pikeminnow can reach full maturity (Lower Columbia Fish Recovery Board 2004b), with a maximum size of 600 mm, 2.5 kg mass, and they can live up to age 16 below Bonneville as well as in the Columbia and Snake reservoirs (Rieman and Beamesderfer 1990; Parker et al. 1995). Spawning occurs primarily when temperatures rapidly rise from 14°C to 18°C (June and July) (Gadomski et al. 2001). Gadomski et al. (2001) found most pikeminnow spawn on dam tailraces rather than elsewhere in the reservoirs. Both larval and juvenile pikeminnow rear along the shoreline where water velocities are low (Gadomski et al. 2001). Poe et al. (1991) found smaller Northern pikeminnow consumed primarily invertebrates, which increased with increasing size. Fish above 375 mm fork length ate more salmonids than invertebrates and other fishes combined (based on percent weight). Salmonids composed 21 percent of diet at 300 mm FL and up to 83 percent of diet of larger fish (475 mm) (Vigg et al. 1992, as cited in Beamsderfer et al. 1996) Juvenile pikeminnow feed primarily on invertebrates and become piscivorous around 2 years of age (Fritts and Pearsons 2006; Martinez Garcia 2014). Smaller pikeminnow, less than 12 inches (30 cm) long, eat chiefly invertebrates, while larger pikeminnow prefer smaller fish such as salmon, sculpins, trout, perch, and suckers (Lower Columbia Fish Recovery Board 2004b). According to Beamesderfer, Ward, and Nigro (1996), pikeminnow prey exponentially more on juvenile salmon as pikeminnow increase in size.

Pikeminnow are important in the Columbia River region as a piscivorous predator of outmigrating salmon smolts. Because of this predation on salmon and steelhead smolts, pikeminnow are harvested as part of Bonneville's pikeminnow reward program. Pikeminnow thrive in the Columbia River Basin primarily because of their ability to adapt to changing water depths, flows, and temperature levels; and because pikeminnow consume a diversity of prey species (Lower Columbia Fish Recovery Board 2004b). Northern Pikeminnow prefer temperatures 16-22°C but are often found in warmer waters (Brown and Moyle 1981). Reservoirs associated with dams provide warm water and low current areas that benefit pikeminnow (Martinez Garcia 2014). Salmon and pikeminnow are both native to the basin, but changes in the system to more reservoir environments favor pikeminnow production and by increasing the metabolism of these predators, resulting in higher than natural predation rates. Because of high predation rates on juvenile salmon, pikeminnow have been targeted for control since 1990 through gillnetting and sport-reward fisheries (ODFW 2018b). These programs have been successful at removing the larger pikeminnow that predate on juvenile salmon.

***Mountain Whitefish***

Mountain whitefish (*Prosopium williamsoni*) is a native member of the Salmonidae family and is not an ESA-listed or state-listed species. Mountain whitefish inhabit lakes and large rivers and medium to large cold mountain streams. As a generalized life history, mountain whitefish spawn from October through December in stream riffles or on gravel shoals in lakes (Wydoski and Whitney 2003). Eggs are broadcast into the water column and are distributed throughout a variety of locations and depths depending on river flow conditions during spawning. Hatching of the eggs is assumed to start in January and potentially extend until May. Juveniles feed primarily on aquatic insect larvae in flowing reaches with a cobble gravel substrate, such as the Hanford Reach of the Columbia River (Wydoski and Whitney 2003). Older juveniles and adults primarily use deep, fast-moving water over gravel and cobble substrates. Mountain whitefish may live to 17 years and grow to maximum sizes of 10 to 23 inches (23.4 to 58 cm) (Scott and Crossman 1998).

Mountain whitefish occur throughout the Columbia River Basin but are rare in the impounded sections of the Columbia and Snake Rivers. An unknown proportion of mountain whitefish in the lower, middle, and upper sections of the lower Columbia River undertake long migrations to spawning areas in other sections of the river (BC Hydro 2014). Mountain whitefish in southern Idaho disproportionately use larger streams (wider than 49 feet [15 m]) in the Snake River Basin compared to more northerly locations, where they are more common in smaller streams (Meyer, Elle, and Lamansky 2009). Fish collection at Lower Monumental, Little Goose, and Lower Granite Dams from 2012 to 2017 generally resulted in increases in mountain whitefish catch during this 6-year period, although fewer fish were caught in 2016 and the increases did not occur every year. Whitefish contribute to recreational fisheries throughout the region.

***Other Native Fish Species***

A variety of native minnow, sculpins, and sucker species contribute ecologically to the fish communities in the study area. Native minnows and sculpins tend to be small and are important prey items for many native or recreationally important key predator species. Suckers typically grow larger and feed on aquatic insects or algae, but juveniles and adults provide a key food source for piscivorous fish, birds, and mammals.

Native minnow species (Cyprinidae family) occur in freshwater streams, lakes, and small- to medium-sized rivers in the Columbia River Basin. Minnows occur in shallow waters, around inshore areas of lakes (peamouths, longnose dace, leopard dace, redside shiner, tui chub, chiselmouth, and young Northern pikeminnow), the slow parts of small- to medium-sized rivers (peamouths, longnose dace, speckled dace, leopard dace, Oregon chub, tui chub, and redside shiner), swiftly flowing creeks (Umatilla dace, longnose dace, and chiselmouth), and in riffles (speckled dace) (International Union for Conservation of Nature 2013). As a generalized life history, minnows spawn at 1 or 2 years of age, with peak spawning occurring in late spring and summer. Most of the species prey on small organisms (zooplankton) or are insectivorous for all or a portion of their life cycles. Trout-perch (also known as sandroller) is another small fish species endemic to small to large rivers in the basin with similar requirements.

Sculpins (Cottidae family) are smaller, bottom-dwelling fish in the family Cottidae. Sculpins occur in cold freshwater streams, lakes, and rivers and are widely distributed in the Columbia River Basin. Most of these species inhabit medium- or larger-sized streams with moderate to rapid current, although some species prefer slow-moving parts of streams, rivers, or lake habitats. Sculpins have been found in springs (mottled and slimy sculpins), lakes (Paiute and prickly sculpins), stream pools (margined and reticulate sculpins), small rivers (shorthead, Paiute, prickly, torrent, and reticulate sculpins), medium-sized rivers (shorthead, Paiute, prickly, torrent, and coastrange sculpins), and large rivers (shorthead, torrent, Columbia, and coastrange sculpins). The coastrange and prickly sculpins occasionally enter estuaries, while slimy sculpin have been found in brackish water. As a generalized life history, sculpins spawn at 1 or 2 years of age, with peak spawning occurring between March and May. Juvenile sculpins initially feed on plankton during their pelagic life stage, transitioning to aquatic insects after moving to stream or lake bottoms where they spend the majority of their life cycles.

Suckers (Catostomidae family) within the Columbia River Basin include largemouth sucker (also known as the largescale sucker), bridgelip sucker, longnose sucker, and mountain sucker. None of these four species are ESA-listed or state-listed. They inhabit a variety of habitats such as pools and runs of large rivers and lakes (largemouth sucker); lake margins and backwaters as well as rocky riffles and runs of small rivers (bridgelip sucker); cold, clear deep waters of lakes and tributary streams (longnose sucker); and rocky riffles and runs of clear mountain creeks (mountain sucker). These species typically feed on algae, diatoms, insects, amphipods, mollusks, and may feed on salmon eggs. Young suckers may by preyed upon by some salmon species (Scott and Crossman 1998).

**Key Non-Native Fish Species**

A non-native or nonindigenous species is a species "not native to a particular area, or found living outside of historical range" (USGS 2018b). A non-native species can be benign, or it can be invasive and potentially harmful. Many non-native species in the Columbia River serve as recreational resources but can cause impacts to native fish through competition and predation. An invasive species is non-native to the ecosystem and is likely to cause economic or environmental harm or harm to human health. Invasive species are capable of causing extinctions of native plants and animals, reducing biodiversity, competing with native organisms for limited resources, and altering habitats.

***Non-Native Salmon and Trout***

Non-native resident salmon and trout present in the Columbia River Basin include Arctic grayling (*Thymallus arcticus*), Atlantic salmon (*Salmo salar*), brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*), golden trout (*O. aguabonita*), lake trout (*Salvelinus namaycush*), lake whitefish (*Coregonus clupeaformis*), and tiger trout (a hybrid of brook and brown trout)

(Novak 2014; Froese and Pauly 2018; USGS 2018a). Introduced resident salmon and trout can have a variety of effects on native endangered salmon and trout, including hybridizing (Seiler and Keeley 2009; Dehaan Schwabe, and Arden 2010; Kanda, Leary, and Allendorf 2011), predating on native fish (Levin et al. 2002; McHugh and Budy 2006; Schoen, Beauchamp, and Overman 2012), competing for food and habitat with native fish (McHugh and Budy 2006; Seiler and Keeley 2009), and introducing parasites and diseases (Krueger and May 1991; Burrill 2014).

Some native and non-native trout species are stocked annually in lakes where they would not naturally occur within all watersheds of the Columbia River Basin including the Clearwater, Kootenai, and Salmon River watersheds (USGS 2018a). Hybridization between cutthroat (*O. clarkii*) and rainbow (*O. mykiss*) trout has been documented in drainages throughout Idaho (Kozfkay et al. 2011). Much of this is unnatural due to past stocking of fertile hatchery rainbow trout (Weigel et al. 2003, Campbell et al. 2002), and much more limited stocking of fertile cutthroat trout (Neville and Dunham 2011) in areas where the two species are not naturally sympatric. Some hybridization also occurs naturally between sympatric populations of cutthroat trout and rainbow trout (Kozfkay et al. 2007). Most of the research in Idaho suggests that although hybrids have been detected in many drainages, hybridization and introgression levels are often low, with few hybrid swarms documented (Meyer et al. 2006; McKelvey et al. 2015). These results have been explained by strong assortative mating observed between rainbow trout and cutthroat trout and the reduced fitness of hybrids (Henderson et al. 2000; Gunnell et al. 2008; Kozfkay et al. 2007; Walters 2006; Young et al. 2003). These hybrids are established in Lake Pend Oreille and the lower Columbia, Clearwater, and Snake Rivers and are stocked annually in lakes within several watersheds including the Clearwater River (USGS 2018a). In some locations, sterile hybrid trout are stocked to provide recreational fishing opportunities without substantially altering the established fish communities. The status of brown trout is unknown (USGS 2018a). Atlantic salmon, brook trout, lake trout, and lake whitefish were introduced from eastern North America (Novak 2014; USGS 2018a). Brown trout were introduced from Europe and Asia, and golden trout were introduced from California (USGS 2018a).

#### *Other Non-Native Gamefish*

Many species of non-native warm water fish in the Columbia River Basin were introduced as recreational game species where they thrive primarily because of habitat modification and the creation of slow-moving water, reservoirs, and warm water habitat. Smallmouth bass, largemouth bass, sunfishes, perch, pike, walleye, and catfish provide recreational resources but have become invasive and compete with or cause predation issues for native fish.

Smallmouth bass and largemouth bass (sunfish; Centrarchid family) were introduced from eastern North America in the 1920s (Sanderson et al. 2009; Carey et al. 2011; Fuller, Cannister, and Neilson 2018). They are aggressive, predatory fish that feed on amphibians, fish, birds, and small mammals. Invertebrates constitute a large part of smallmouth bass diet, particularly crayfish and other crustaceans (Poe et al. 1991). Preferred spawning habitat for both species includes slow-water areas of lakes, rivers, or streams in water less than 18 to 20 feet deep.

Once eggs hatch, optimal juvenile fish growth is associated with water temperatures between 26°C and 29°C (Wile 2014). Juvenile bass become piscivorous around 2 years old at approximately 100-150mm in length (Fritts and Pearsons 2006) and live long life spans. Bass are now established and breeding throughout the Columbia River Basin, and they continue to be stocked in some locations (Sanderson et al. 2009; USGS 2018a). Carey et al. (2011) note several studies that predict the expansion of suitable habitat for bass with warming temperatures, which could facilitate an increase in bass populations.

Other non-native sunfish present in the Columbia and Snake Rivers include black crappie, bluegill, pumpkinseed, rock bass, striped bass, warmouth, and white crappie (Froese and Pauly 2018; USGS 2018a). Sunfish occur in streams, lakes, and reservoirs (Froese and Pauly 2018). Black crappie, striped bass, and white crappie prey on juvenile salmon and native resident fish as adults and compete with native fish for invertebrates, zooplankton and small fish as juveniles (Riso 2011; Froese and Pauly 2018; USGS 2018a). Pumpkinseed, rock bass, warmouth, spotted bass, and bluegill compete with native fish by preying on invertebrates and small prey fish (Spurr 2008; West 2009; Arterburn 2014; Park 2014; Froese and Pauly 2018). As a family, sunfish in the Columbia River Basin can tolerate a wide range of water temperatures 0°C to 32°C (Froese and Pauly 2018).

Walleye (*Sander vitreus*) is a member of the perch family that was introduced to the Pacific Northwest in the mid-1900s from eastern North America (Sanderson et al. 2009; Froese and Pauly 2018). Carp, suckers, and sculpins appear to be more important in walleye diets than juvenile salmon (Zimmerman 1999); however, the walleye population in the Columbia River can consume as many as 2 million juvenile salmon per year (Rieman et al. 1991; Sanderson et al. 2009). Poe et al. (1991) found juvenile salmonids were the most important prey (27-60 percent of diet) for walleye less than 300 mm fork length but were frequently of secondary importance for larger walleye (350mm +). Fish composed nearly 100 percent of walleye diet in The Dalles and John Day reservoirs (Williams et al. 2019), and salmonid prey items had the greatest frequency of occurrence in walleye diets than any other prey fish family. Walleye can reach a maximum size of 42 inches long and 24 pounds (107 cm long and 10.9 kg), with a maximum age of 29 years (Wydosky and Whitney 2003). According to Caisman (2011), walleye spawn in spring when the water temperature warms to 3.9°C over a variety of benthic habitats less than 10 feet (3 m) deep. Walleye mature between 2 and 6 years depending on water temperature and their density in the waterbody (Lower Columbia Fish Recovery Board 2004a; Schueller et al. 2005; Caisman 2011). Juvenile walleye initially feed on zooplankton and then switch to benthic macroinvertebrates prior to becoming piscivorous (Caisman 2011). Juvenile walleye are found near the surface while adult walleye prefer deeper water (Lower Columbia Fish Recovery Board 2004a) and have diurnal movements, using deep habitats during the day and shallow habitats at night for feeding (Wydoski and Whitney 2003). Juvenile walleye survival may be limited by changes in water flows. Increased flows can transport juvenile walleye or their prey to less advantageous areas (Lower Columbia Fish Recovery Board 2004a).

Historically, walleye were introduced to Lake Roosevelt and have since dispersed throughout the Columbia River Basin (Caisman 2011) and are established and breeding; suppression efforts by WDFW and the UCUT tribes are aimed at keeping northern pike from becoming widely established in Lake Roosevelt. According to Sanderson et al. (2009), anglers in the Columbia River Basin have caught some of the largest walleye ever recorded at 19 pounds (8.6 kg) in Oregon (ODFW 2018c) and 20 pounds (9.1 kg) in Washington (WDFW 2018). Reservoirs associated with dams provide warm water, low currents for juvenile walleye, and deep pools that benefit adult walleye (Lower Columbia Fish Recovery Board 2004a).

Yellow perch (*Perca flavescens*), introduced from eastern North America in the late 1800s for fishing and sport fish bait (Harmon 2011), are another perch species well-suited to the reservoir conditions present in the basin. Yellow perch can tolerate a wide range of water temperatures 0°C to 30°C (Froese and Pauly 2018). Juvenile yellow perch prey include macroinvertebrates and zooplankton (Froese and Pauly 2018), which reduces prey availability for native fish (Hughes and Herlihy 2012). Once yellow perch reach three years old, they begin to prey on fish as well, including juvenile salmon (Dephilip and Berg 1993; Sanderson et al. 2009).

Four non-native pike species (Esociformes order) occur in the Columbia River Basin. Central mudminnow, northern pike, grass pickerel, and tiger muskie were introduced from eastern North America (Froese and Pauly 2018; USGS 2018a). Tiger muskies, a hybrid between northern pike and muskellunge, are stocked in lakes within the Columbia River Basin (USGS 2018a). Northern pike and grass pickerel are established and breeding in the Columbia River above Grand Coulee Dam, and grass pickerel are established and breeding in the lower Snake River (USGS 2018a).

Northern pike (pike; *Esox lucius*) are resident, freshwater fish that inhabit ponds, slow-moving lakes, and rivers. In the Columbia Basin, they are an invasive species. Pike prefer water temperatures from 10°C to 28°C (Froese and Pauly 2018) and shallow water with benthic vegetation to better ambush their prey (Hennessey 2011). Pike are well-known ambush predators that feed on native fish species and macroinvertebrates (Craig 2008; McMahon and Bennett 1996). Sepulveda et al. (2013) found that juvenile salmon dominated northern pike diet when salmon were present; but pike selected other resident fish for consumption when salmon were not available, thereby impacting both salmon and resident fish. Because of the strong appetite and prolific spawning capabilities of pike, fisheries managers in Washington are concerned that, if pike spread from their current range above Grand Coulee Dam into the Columbia and Snake Rivers below Grand Coulee, they will further endanger ESA-listed salmon (WDFW 2018g). Because of the concern for resident fish, pike are classified as a prohibited species in Washington (WDFW 2018b); however, pike are listed as a gamefish in Idaho and Montana (Idaho Department of Fish and Game [IDFG] 2013; FishMT 2018). Multiple pike suppression efforts are underway with multiagency funding and support, such as “Northern Pike Suppression and Monitoring,” the joint project between the Confederated Tribes of the Colville Reservation, Spokane Tribe of Indians, and WDFW. Additionally, the Columbia River Inter-Tribal Fish Commission encourages tribal fishers to kill any pike and tiger muskie between Bonneville Dam and McNary Dam to document species presence in the Columbia River (CRITFC 2018b).

Non-native catfish (Ictaluridae family) occur in the Columbia River Basin and include black bullhead, channel catfish, brown bullhead, flathead catfish, tadpole madtom, and yellow bullhead. The four species were introduced from eastern North America (Froese and Pauly 2018; USGS 2018a). Brown bullhead and channel catfish are abundant and reproducing naturally (WDFW 2018f, 2018g). Black bullhead, flathead catfish, and yellow bullhead are less common, but present (WDFW 2018e, 2018i; USGS 2018a), while there is little information on tadpole madtom and blue catfish populations.

Catfish are resident, freshwater fish that live primarily near the bottom of slow-moving lakes and rivers. As a family, catfish can tolerate a wide range of water 0°C to 37°C and water conditions (Froese and Pauly 2018). With the exception of the tadpole madtom, of which little is known, all species are predators of native fish and may reduce native fish and invertebrate diversity and abundance (Hughes and Herlihy 2012; USGS 2018a). Hughes and Herlihy (2012) noted that on rivers where non-native species were frequently caught, some historically present native fish were missing or caught in lower numbers than expected. Channel Catfish were considered in the original Northern Pikeminnow Management Program (NPMP) studies but ultimately excluded because, per capita, they constitute a relatively low predation burden (Poe et al. 1991). Almost all channel catfish predation on juvenile salmonids, characterized in earlier studies, occurred in tailrace areas and was confined to spring season, likely due to distribution of channel catfish, which appear to congregate in the upper part of JDA in the spring.

***Other Non-Native Fish***

Non-native minnow species include common carp, fathead minnow, goldfish, grass carp, and tench (Froese and Pauly 2018; USGS 2018a). Minnows are resident, freshwater fish in slow-moving lakes and rivers with dense aquatic vegetation. As a family, minnows can tolerate a wide range of water temperatures 0°C to 38°C and water conditions including low oxygen and high turbidity (Froese and Pauly 2018). Non-native minnows feed on zooplankton, macroinvertebrates, and aquatic vegetation (USGS 2018a). Kaemingk et al. (2016) found common carp affects native resident fish species by increasing turbidity when it uproots benthic vegetation while feeding and competes for invertebrate prey. Other minnow species also increase turbidity and decrease aquatic vegetation when feeding on benthic vegetation (USGS 2018a). Fathead minnow competes with native fish for habitat and food and is a prohibited species in Washington (Holzman 2014; WDFW 2018d).

Other non-native small fish include brook stickleback (*Culaea inconstans*), banded killifish (*Fundulus diaphanus*), mosquitofish (*Gambusia affinis*), and goby. These fish have been introduced into the system through transportation of bait, intentional introductions, or accidental introductions via ballast water or aquarium trade. These are all small, typically less than 4 inches (10 cm) long and typically feed on algae, eggs, larvae, and invertebrates. They provide prey items for piscivorous predators, but also may contribute to the decline of native species via competition and predation of eggs.

## REGIONAL RESIDENT FISH COMMUNITIES

This section describes the regional resident fish communities in the Columbia River Basin. The Basin has been divided into regions based on similar features such as lakes, rivers, streams, what resources are present, and how they are managed. Resident fish communities can vary by region because of limited distributions, passage barriers, specialized habitat requirements, unique life histories, or area of introduction for non-native species. As a result, resident fish communities are managed on a localized scale as compared to anadromous species. The previous sections described the life history and requirements for each species, whereas this section discusses effects to fish communities in each of these regions. The regions are discussed beginning with the uppermost area of the waterbodies affected by CRS projects and follows the water downstream to the mouth and estuary of the Columbia River.

### Region A

#### ***Kootenai River (Lake Koocanusa to U.S.-Canada Border) Region***

Lake Koocanusa is a reservoir formed by Libby Dam on the Kootenai(y) River (Figure 3-127). It is a long reservoir (about 90 miles [145 km] long) with about half in Montana and half in British Columba. Downstream from Libby Dam, the Kootenai(y) River passes over Kootenai Falls 9 miles west of the town of Libby, Montana. The river flows northwesterly through Troy, Montana, and Bonners Ferry, Idaho, eventually turning north and meandering north to cross the border back into British Columbia.


**Figure 3-127. Study Area for Kootenai River (Lake Koocanusa to U.S.-Canada Border) Region**

Bull Trout

In the Kootenai River drainage, three distinct populations of bull trout exist: one downstream of Kootenai Falls, one between the falls and Libby Dam, and one upstream of Libby Dam.

Upstream of Libby Dam, Lake Koocanusa is one of the most secure and stable bull trout refugia across the range of the species, though most of the spawning and rearing habitat is in British Columbia (USFWS 2010). Adfluvial bull trout, originating from fluvial stocks in the Kootenai River that were trapped upstream of Libby Dam, are the only bull trout life history form present in the lake. Canadian headwaters (Kootenay River tributaries and Wigwam River) are believed to support the strongest populations (Marotz et al. 2001). Bull trout in Canada are not subject to protections under the U.S. ESA. The strongest U.S. population upstream of Libby Dam is in Grave Creek (including Clarence and Blue Sky Creeks) in the Tobacco River drainage with 94 to 245 redds per year counted between 1999 and 2008 (USFWS 2010).

Below Libby Dam, the bull trout population uses four tributaries upstream of Kootenai Falls, but contains too few individuals and subpopulations to be considered stable. Below Kootenai Falls, bull trout are found in O'Brien Creek, Callahan Creek and in Bull Lake. The latter is a disjunct population that migrates out of Bull Lake, downstream to Lake Creek then upstream in Keeler Creek. These fish inhabit areas in the lower Kootenai River and Kootenay Lake during most of the year.

Kootenai River White Sturgeon

Approximately 8,000 sturgeon are estimated to have been present in the Kootenai River system in the late 1970s (Paragamian, Beamesderfer, and Ireland 2005). The wild sturgeon population declined from approximately 3,000 individuals in 1990 to 990 in 2011 (Beamesderfer et al. 2014a); the current wild population largely consists of an aging generation of large, old fish. The wild population was found to decline most rapidly from 2008 to 2011 because of decreased survival rates (97 percent annual survival prior to 2008 and 85 percent from 2007 to 2011), presumably, because of increased adult age; sturgeon can live more than 80 years. Low levels of natural recruitment continue, based on low sample numbers of juvenile fish; Beamesderfer et al. (2014a) estimated natural recruitment (i.e., offspring from spawning, not from hatcheries) to the wild population of 13 fish per year.

The size and age at which white sturgeon are sexually mature varies, but females are estimated to begin to be mature at 30 years and males at 28 years (Paragamian, Beamesderfer, and Ireland 2005). Kootenai River white sturgeon do not spawn each year; females spawn about every 3 years, while males spawn approximately in alternate years (USFWS 1999). Kootenai River white sturgeon express a unique, two-step spawning pattern, migrating to staging reaches from the lower Kootenai River and Kootenay Lake, and then on to spawning reaches near Bonners Ferry, Idaho, in the spring (Paragamian 2012). The substrate at current spawning sites in the Kootenai River is much finer than the rocky substrate found in successful white sturgeon spawning sites elsewhere in the Columbia River Basin.

Spawning in sandy locations may lower survival if sand or silt covers the embryos (McDonald et al. 2010). It was speculated that prior to the completion of Libby Dam, this area was likely scoured of sand during high river flows that re-sorted river sediments, providing clean cobble substrate conducive to egg incubation (USFWS 1999). Research revealed that Kootenai River white sturgeon are likely spawning in the same locations as pre-dam, but dam operations have reduced velocities and shear stress; therefore, sediment is now covering the cobbles and gravels (Paragamian et al. 2009).

White sturgeon are broadcast spawners, which means females typically release eggs over an area, then males release milt (i.e., sperm) over the eggs to fertilize them (Scott and Crossman 1973; McDonald et al. 2010). Kootenai River white sturgeon spawn when water temperature is 8.5°C to 12°C (McDonald et al. 2010; Paragamian 2012). After fertilization, their eggs adhere to the riverbed and incubate for 8 to 15 days (Brannon et al. 1985). White sturgeon remain attached to the yolk after hatching, and they begin to forage as “free embryos” until the yolk is depleted after about 7 to 11 days (USFWS 2006). At this time, the larval white sturgeon are distributed by the currents and the juveniles and adults rear in the Kootenai River and in Kootenay Lake (USFWS 2006).

The Kootenai Tribe’s sturgeon aquaculture program, funded by Bonneville, was established in 1988 to prevent extinction, preserve the gene pool, and continue rebuilding a healthy age class structure for this endangered population using conservation aquaculture techniques with wild native broodstock (Kootenai Tribe of Idaho [KTOI] 2012). The wild population of white sturgeon has been augmented with the release of juvenile white sturgeon reared at the tribal hatcheries (USFWS 1999). Fish releases continue pursuant to the Kootenai Tribe of Idaho’s USFWS Section 10 permit. Annual releases have ranged from 3,000 to 37,000 fish per year from 2003 to 2013 and with an average annual release of 20,000 fish; from 2008 to 2013, releases have averaged 18,000 fish (Bonneville 2013).

<u>Fish Communities</u>

*Lake Koocanusa (Libby Reservoir)* – The reservoir supports an important fishery for kokanee and rainbow trout. Burbot are another important gamefish, but their population level has become severely suppressed, and can no longer provide a fishery. Bull trout serve as an intermittent (not every year) sport fishery under Section 4(d) of the ESA; when redd counts meet or exceed established criteria, a limited entry sport fishery is open on the reservoir the following year (subject to Montana fishing regulations), with anglers allowed to keep one bull trout per year. Several warm water species such as largemouth bass, pumpkinseed, and yellow perch inhabit the reservoir but are present only in low numbers compared to other locations where their populations cause problems for native species. The Gerrard strain of rainbow trout, native to Kootenay Lake in British Columbia, is cultured at Murray Springs Fish Hatchery by MFWP. This subspecies attains tremendous size by becoming piscivorous (i.e., eats other fish) at age 2 to 3 years, and has been stocked in the reservoir in increasing numbers since 2006. The average number of Gerard rainbow trout that MFWP stocked from 2010 to 2012 was 32,000 fish per year, and the average for 2016 to 2018 was roughly 70,000 per year (MWFP 2018). The objective for Gerrard rainbow trout in the reservoir is to develop a trophy rainbow trout fishery as well as provide a natural predator on kokanee; a reduction in kokanee numbers in the reservoir would likely increase their average size because of less competition for food, and thus improve the fishery according to angler preference for larger fish. Thus far, the population structure of Gerrard rainbow trout in the reservoir has yet to achieve the density required to reduce kokanee densities or to provide growth opportunities for larger, piscivorous individuals.

The upper portion of Koocanusa Reservoir still contains some genetically pure stocks of fluvial and adfluvial westslope cutthroat trout. In the western United States, however, distribution of westslope cutthroat trout has declined dramatically from historical levels over the past 30 years, and they now occupy only about 59 percent of lotic (i.e., flowing) habitats of their former range (Shepard et al. 2005).

*Kootenai River* – The Montana portion of the Kootenai River downstream of Libby Dam supports a relatively stable and abundant recreational trout fishery of non-native rainbow trout that account for about 10 to 15 percent of the total fish assemblage according to electrofishing surveys conducted in 2008 (Gidley 2010). Mountain whitefish are the most abundant fish species in the Montana portion of the Kootenai River, constituting approximately 60 to 70 percent of the total fish assemblage, but are seldom targeted by anglers (MFWP unpublished data; Gidley 2010). Since the construction of Libby Dam, the Idaho portion of the mainstem Kootenai River fish community has shifted from being dominated by whitefish and trout to consisting primarily of suckers, peamouth chub, and northern pikeminnow.

In the present conditions of Kootenai River, the primary habitat factors limiting resident fish include an altered hydrograph and riparian condition, elevated turbidity and fine sediments, reduced connectivity, and an altered thermal regime (Kootenai Tribe and MFWP 2004). Reduced phosphorus loading to the Kootenai River downstream of Libby Dam limits productivity of resident fish in this reach (Kootenai Tribe and MFWP 2004). In response to this limiting factor, the KTOI and the Idaho Department of Fish and Game co-manage the Kootenai River Ecosystem Improvement Project, which includes nutrient restoration and extensive monitoring of baseline conditions and the effects of the nutrient restoration. The goal of this project is a productive, healthy, and biologically diverse Kootenai River ecosystem, with emphasis on native fish species including white sturgeon, burbot, bull trout, and kokanee. Preliminary results suggest the project has substantially increased ecosystem productivity in the nutrient addition zone of the Kootenai River and the South Arm of Kootenay Lake (Holderman 2012).

Burbot had been a valuable sport and commercial fishery in the Kootenai River; however, the fishery collapsed following the construction of Libby Dam. The fishery peaked in the late 1960s with over 25,000 burbot harvested annually, and by 1987, none were harvested (Paragamian et al. 2000). The average abundance estimates for 1997 to 2003 were only 150 to 200 adult burbot in the Kootenai River (Paragamian et al. 2004). However, a burbot restoration program including extensive conservation aquaculture was established in 2014 by KTOI and IDFG, in cooperation with BC. The program is meeting several objectives including the ability to sustain a harvest fishery, which was re-opened in January of 2019. Current abundance was estimated at 20,000 adults in 2019 (Young, S. and R. Hardy. 2019. KTOI and IDFG, Presentation NW Power and Conservation Council). Burbot are listed as a species of special concern in Idaho and Montana.

Native kokanee salmon runs in lower Kootenai River tributaries in Idaho have experienced significant population declines during the past several decades (Paragamian 1994; Ashley et al. 1997). Adult kokanee in tributaries ranged from about 3,800 to 6,600 fish counted per survey in the early 1980s and dropped to fewer than 10 counted per survey in the early 2000s (Ericksen et al. 2009). In the Idaho reach of the Kootenai River, westslope cutthroat trout are not common and provide only a small portion of the salmonid harvest (Paragamian 1994). Native interior redband, a subspecies of rainbow trout and designated a species of special concern in Montana, exist in only a few isolated Kootenai River tributaries (Callahan and Libby Creeks and tributaries to the Yaak and Fisher Rivers). Mountain whitefish abundance has declined in the Idaho reach of the Kootenai River since the early 1980s, despite availability of ideal spawning habitat (Paragamian 1994; Downs 1999). Reduction in productivity of the Kootenai River was identified as the cause for declining mountain whitefish abundance, so liquid phosphate fertilizer has been added to the river since 2005 to increase phosphorus concentrations in the river to pre-dam levels (14,000 to 16,000 fish; Ross et al. 2018). By 2008, the mountain whitefish population rose to over 17,000 fish and exceeded levels documented in 1980; the population then dropped below this target in 2014 and 2016, potentially because the population has reached capacity and has begun to stabilize (Ross et al. 2018).

Preliminary important environmental relationships for resident fish in this region that could be affected by MOs are as follows:

- High and prolonged peak flows and the shape of the freshet are important for Kootenai River white sturgeon spawning. The difference between the winter peak and the spring freshet are also important for riparian community that supports native fish food supply.
- Libby Reservoir temperatures are important to support Kootenai River white sturgeon, bull trout, and other native fish.
- Libby elevation influences discharge temperature in late winter/early spring, with higher elevations resulting in cooler discharge. Warmer water (10°C) is needed for sturgeon spawning.
- Kootenai River temperatures at Bonners Ferry of 8.5° C to 12° C supports sturgeon spawning, and an appropriate progression from 2°C to 14°C from mid-February to mid-April is needed for the biological progression of Kootenai River white sturgeon and burbot physiology.
- Outflow during March through mid-April influences entrainment rates of burbot through Libby Dam, with higher flows resulting in increased entrainment. For kokanee, entrainment rates are influenced by outflow in early spring and mid-summer.
- River elevation at Bonners Ferry affects floodplain connectivity to off-channel habitats for burbot and other native fish.
- Libby Dam discharge in winter should be low, steady flow, and cold temperature for burbot. High and variable flows can interrupt spawning.

- Libby Reservoir elevation during summer months determines productivity of plankton to support forage species. In addition, the minimum Libby elevation in one year influences insect larva production the following year, and the maximum elevation is related to the volume and surface areas and the proximity of the surface to terrestrial insect production, which is also important to bull trout food production. This food web is especially important to bull trout, westslope cutthroat trout, redband rainbow trout, and kokanee.

***Flathead and Clark Fork Rivers from Hungry Horse Reservoir Tributaries to Montana-Idaho Border***

The study area for this region (Figure 3-128) includes from the tributaries to Hungry Horse Reservoir following the flow of water downstream to where the Clark Fork River flows across the Montana-Idaho border. Specifically, starting with tributaries of Hungry Horse Reservoir, water flows through the reservoir, through the dam outlet into South Fork Flathead River, which then flows into the Flathead River near Columbia Falls. The Flathead River flows downstream through the Flathead Lake (a large natural lake), past Seli'š Ksanka Qlispe' Dam (formerly referred to as Kerr Dam) (a non-Federal dam), and joins the Clark Fork River near Paradise, Montana. The Clark Fork River continues through a series of non-federal hydropower projects (Thompson Falls, Noxon Rapids, and Cabinet Gorge). The Cabinet Gorge Reservoir pool is mostly in Montana, with the dam just across the state border in Idaho. This analysis region's downstream extent is the state border.

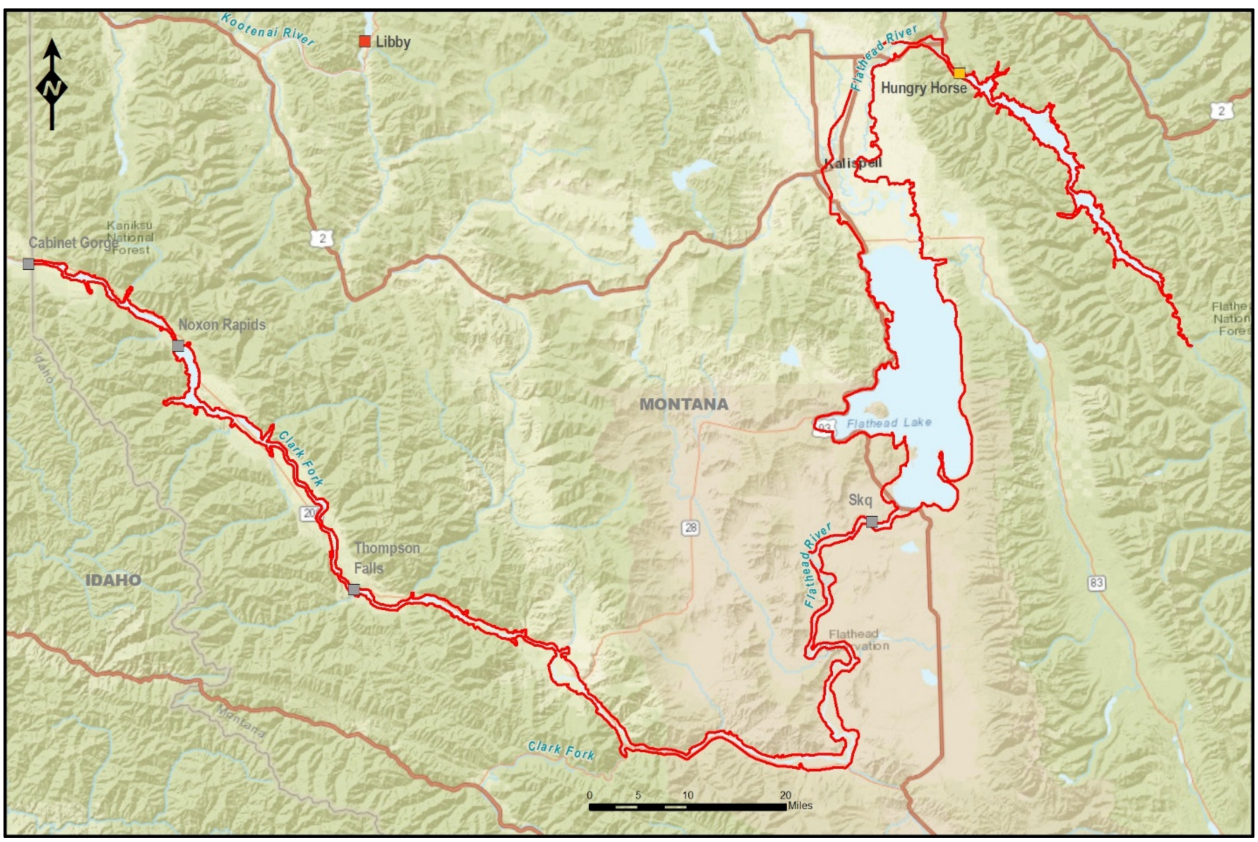



**Figure 3-128. Study Area for the Flathead and Clark Fork Rivers from Hungry Horse Reservoir Tributaries to Montana-Idaho Border**

Bull Trout

Hungry Horse Reservoir contains a substantial population of 2,500 to 10,000 adfluvial bull trout that are stable in number (USFWS 2008a). Hungry Horse is among the most robust and least threatened populations of bull trout in the recovery area (USFWS 2015). The population is strong enough to allow for a limited harvest fishery, ongoing since 2004. These bull trout spawn in the tributaries above Hungry Horse Reservoir and the South Fork Flathead River upstream of the reservoir. Hungry Horse Reservoir is designated critical habitat for bull trout (75 FR 63898). Within this area of bull trout habitat, Hungry Horse Dam operations affect reservoir levels and water temperatures, which influences bull trout habitat and food production.

The South Fork Flathead River below Hungry Horse Dam is only transitional habitat for bull trout as very few from Hungry Horse Reservoir populations are entrained through the dam downstream into this reach. Bull trout from the Flathead River wander into this reach occasionally, but there has been no documentation of spawning by bull trout in this reach. The few juvenile and subadult bull trout may use this transitory habitat more frequently due to improved temperatures after the installation and operation of a selective withdrawal-temperature control device at Hungry Horse Dam. This reach of the South Fork Flathead River is not designated critical habitat for bull trout.

Flathead Lake adfluvial bull trout reside in Flathead Lake and migrate to spawn in tributaries of the North Fork and Middle Fork Flathead Rivers, and occasionally in the South Fork Flathead River. In early summer, adult adfluvial bull trout migrate from Flathead Lake into the river and move toward staging areas. They then move into spawning tributaries in August, and following spawning in September, move rapidly (within several days) back downstream to Flathead Lake (Confederated Salish and Kootenai Tribes [CSKT] and MFWP 2004, as cited in Corps 2006). Fluvial populations of bull trout spawn and rear in Flathead River tributaries and move downstream to mature and reside in the Flathead River (CSKT and MFWP 2004, as cited in Corps 2006). The Flathead River and Flathead Lake are included in designated critical habitat for bull trout (70 FR 56212).

It is assumed that prior to dams being built on the Clark Fork and the lower Flathead River supported the Lake Pend Oreille-Clark Fork River bull trout metapopulation and hosted a considerable migratory component. Today, bull trout exist as relatively isolated populations of likely less than 100 spawning adults in the Jocko River drainage, and bull trout use the Mission Creek drainage only as a migratory corridor (CSKT and MFWP 2004, as cited in Corps 2006). Bull trout found in the lower Flathead River are likely those that were entrained through Seli'š Ksanka Qlispe' Dam (formerly Kerr Dam) or upstream migrants from the Clark Fork River.

Thompson Falls, Noxon Rapids, and Cabinet Gorge Dams have a series of impoundments stretching over 70 miles of the Clark Fork River. These dams were an interruption of bull trout migration and blocked access from portions of the tributary system to the productive waters of Lake Pend Oreille and Flathead Lake. However, substantial effort was made to reconnect these areas. Cabinet Gorge Dam has a trap and haul program that started in 2001, and permanent passage is expected beginning in 2020 or soon thereafter; Thompson Falls Dam had a fish ladder installed in 2010; Noxon Dam has a trap and haul program that started in 2017. The remaining habitat is degraded for bull trout because of water temperature and water quality (USFWS 2002, as cited in Corps 2006).

The expansion of non-native competitive species such as lake trout, northern pike, and brook trout, as well as forestry practices, livestock grazing, agricultural water withdrawals, transportation systems, mining, impoundments, and other development activities have impacted and continue to affect bull trout in the lower Clark Fork River. Since construction of the dams that blocked migration routes, the catch of bull trout during gill net surveys in the reservoirs (between 1960 and 1985) indicates bull trout declined in Noxon Reservoir but remained somewhat stable in Cabinet Gorge Reservoir (USFWS 2002, as cited in Corps 2006).

In the tributaries of the Clark Fork River, spawning and rearing habitats for bull trout remain, but foraging, migrating, and overwintering habitats for migratory adult and subadult bull trout are largely degraded or gone. Over time, the fish expressing the migratory life history pattern (fluvial and adfluvial) of the lower Clark Fork River were largely replaced by bull trout that expressed the resident life form in the tributaries, thus reducing genetic diversity and geographic range (USFWS 2002, as cited in Corps 2006).

Fish Communities

*Hungry Horse Reservoir* – Hungry Horse Reservoir contains primarily native fish species, including westslope cutthroat trout, mountain whitefish, and bull trout. Hungry Horse Dam has helped isolate the native fish populations in most of the South Fork Flathead River drainage from non-native species (such as lake trout), which occur downstream from the dam. Consequently, the reservoir's population of westslope cutthroat trout is one of the most secure metapopulations in existence compared to other reservoirs that have a higher number of introduced species that are competitors or predators (Shepard et al. 2003). Non-game species include northern pikeminnow, largescale and longnose suckers, and sculpins.

MFWP does not artificially stock the reservoir, and fish populations are maintained solely through natural spawning and rearing. Westslope cutthroat and bull trout are the most important game fish species. When sexually mature, these fish migrate to and spawn in the tributary streams that feed the reservoir, including the South Fork Flathead River upstream of Hungry Horse Reservoir and its tributaries. Juvenile fish typically rear in these streams for 3 years before they migrate downstream to the reservoir where they grow to maturity. Beginning in 2004, an experimental bull trout season was initiated that allowed limited (two per year) angler harvest of bull trout from Hungry Horse Reservoir (CSKT and MFWP 2004).

*South Fork Flathead River* – Most of the fish species in the South Fork Flathead River below Hungry Horse Dam and the mainstem Flathead River spend a large portion of their life in Flathead Lake. Native game fish species in the South Fork River and the mainstem Flathead River include mountain whitefish, westslope cutthroat trout, and bull trout. Non-native species include lake trout, rainbow trout, lake whitefish, and kokanee.

Since 1995, with operation of the selective withdrawal system and VarQ, releases from the dam follow a more natural thermal regime approximating conditions in the unregulated reach of the Flathead River. The observed trend is increasing numbers of native trout, no lake trout, and very few brook trout, increasing numbers of bull trout and very high numbers of westslope cutthroat trout. MFWP (personal communication, Brian Marotz 2015) indicated mountain whitefish numbers have increased since operation of the selective withdrawal system.

Hybridization between rainbow and westslope cutthroat trout is prevalent in the upper Flathead River. Hybridization, competition, and loss of habitat have contributed to declines of westslope cutthroat trout, but they are still widely distributed in tributary streams. Westslope cutthroat trout and bull trout grow to sexual maturity in Flathead Lake and migrate up the Flathead River to spawn and rear in tributaries. Juvenile cutthroat trout and bull trout leave rearing streams in early summer and remain in the reach throughout summer and fall as they move downstream to Flathead Lake. Fluvial populations of cutthroat trout spawn in tributaries but mature in the mainstem Flathead River without spending time in Flathead Lake.

*Flathead Lake* – Flathead Lake is colder and less productive but with better water quality compared to most large lakes in the world (CSKT and MWFP 2004, as cited in Corps 2006). The lake supports native bull trout, westslope cutthroat trout, mountain whitefish, largescale and longnose suckers, northern pikeminnow, peamouth chub, redside shiner, and longnose dace. At least 11 non-native fish species have been introduced (legally or illegally) into the system since the late nineteenth century. Historically, bull trout and westslope cutthroat trout were the dominant piscivorous fishes in Flathead Lake. The introduction of non-native fish, coupled with the introduction of the non-native opossum shrimp (*Mysis relicta*) in Flathead Lake, has caused widespread changes in the lake's food web and ecosystem (CSKT and MFWP 2004, as cited in Corps 2006). Lake trout and northern pike are now the dominant predator fish species in the lake (CSKT and MFWP 2004, as cited in Corps 2006). Kokanee, once the dominant fish of Flathead Lake with more than 100,000 spawners in the 1980s, have nearly disappeared such that no fishery is possible. Westslope cutthroat trout and bull trout populations have declined as well.

Lake trout (*Salvelinus namaycush*) were introduced in 1905 and are now a primary factor in reduction of the native salmonid populations in Flathead Lake. The total population grew from about 2,000 lake trout in 1999 to about 36,000 in 2005 (Hansen et al. 2008); the population is most recently estimated at nearly 800,000 fish (Hansen, Hansen, and Beauchamp 2016). Recreational fisheries and lake trout removal by the CSKT are controlling the population, but an increased fishing effort is needed to enable bull trout recovery (Hansen, Hansen, and Beauchamp 2016). Other abundant non-native fish species found in Flathead Lake include lake whitefish, brook trout, and yellow perch.

*Lower Flathead River* – Downstream from Flathead Lake, in the lower Flathead River, prominent fish species include mountain whitefish, brown trout, rainbow trout, northern pike, largemouth bass, cutthroat trout, and northern pikeminnow. Introduced species have affected native species, such as bull trout. Historical operations of Seli'š Ksanka Qlispe' Dam inundated vegetated areas and changed shoreline areas to mud and rock (CSKT and MFWP 2004, as cited in Corps 2006). However, new minimum flows established by Federal Energy Regulatory Commission (FERC) relicensing in 1995 have had resulted in stabilized water releases that more closely approximate the natural flow regime (CSKT and MFWP 2004, as cited in Corps 2006). These changes are expected to substantially improve habitat conditions for aquatic species on the lower Flathead River (CSKT and MFWP 2004, as cited in Corps 2006).

*Clark Fork River* – The Clark Fork between Lake Pend Oreille and the Flathead River hosts 29 fish species. The most common fish are sunfish, yellow perch, northern pikeminnow, shiners, suckers, and bass (FERC 2000). Salmonid populations in the reservoirs are relatively small yet self-sustaining and consist primarily of westslope cutthroat trout, rainbow trout, brown trout, brook trout, bull trout, lake whitefish, and mountain whitefish. The section of the Clark Fork River from the confluence with the Flathead River downstream at RM 245 passes through several run-of-river hydroelectric dams at Thompson Falls, Noxon Rapids, and Cabinet Gorge before flowing into Lake Pend Oreille. Noxon Rapids and Cabinet Gorge Dams were previously barriers to upstream fish movement at all times of the year, but more recently have had trap and haul programs. As a result, they have isolated fish populations, selecting against migratory life histories for westslope cutthroat trout (FERC 2000, as cited in Corps 2006).

The Cabinet Gorge and Noxon Reservoirs are long (10 to 35 miles [16 to 56 km]) and experience water temperatures that range up to 24°C during the warmest part of the summer. Because of this, warm and cool water species such as largemouth and smallmouth bass thrive and cold water fisheries are not present (FERC 2000, as cited in Corps 2006). These projects now support productive bass fisheries. Attempts at establishing a cold water fishery on the Cabinet Gorge and Noxon Reservoirs were unsuccessful even with stocking efforts (FERC 2000, as cited in Corps 2006).

Preliminary important environmental relationships for resident fish in this region that could be affected by MOs are as follows:

- Hungry Horse Reservoir elevations affect primary productivity and zooplankton production important to the fish community, including those that provide the food source for bull trout. Higher lake elevations in the warm summer months provide better conditions, and the maximum elevation draft in a given year affects insect larvae production the following year with deeper maximum drafts resulting in less food supply. The rate of Hungry Horse drawdown and refill also affects food production with a gradual rate maximizing productivity compared to a faster rate.
- Hungry Horse Reservoir elevations influence exposure to angling exploitation and predation, as well as access to spawning areas for bull trout, westslope cutthroat trout, and other native fish.
- Water temperatures affect habitat suitability; the thermal structure of the pool is affected by the surface elevation.

- Entrainment out of Hungry Horse Reservoir is believed to occur to some extent but not measured; entrainment could change with different outflows.
- Within day fluctuations in Hungry Horse Dam outflows and river elevations below the dam affect productivity in the South Fork Flathead River.
- Bull trout and other fish below Hungry Horse Dam can be susceptible to GBT effects if TDG increases.
- The South Fork Flathead River has a more normalized temperature regime that improves native fish habitat due to selective withdrawal at Hungry Horse outlet; changes in Hungry Horse Reservoir elevations could reduce the ability to operate selective withdrawal structures as designed and thereby limit the more normalized temperature regime. Water temperatures affect the suitability for bull trout and other native fish, as well as the ability for them to compete with non-native fish.
- Minimum instream flows of 400 to 900 cfs (sliding scale) protect habitat in the South Fork Flathead River.
- Higher than normal flows from flow augmentation in summer can decrease suitability of habitat for native fish; higher flows in winter can hinder establishment of riparian vegetation and reduce suitability of habitat for native fish.
- Increased outflows from Hungry Horse Reservoir increase the effect of lake erosion at the upper end of Flathead Lake.
- Decreased spring peaks in the hydrograph of the Flathead River leads to less frequent channel maintenance flows; higher and more frequent peaks help maintain habitat for native fish.
- Inflows to Flathead Lake determine lake operations; differing operations could affect fish in Flathead Lake via temperature changes, entrainment of fish through Seli'š Ksanka Qlispe' Dam (the operating structure for Flathead Lake), and effects to the mysis population that supports lake trout.
- Flows in the Clark Fork River affect the suitability for native fish to compete with non-native fish such as smallmouth bass and northern pike. Increased flows can increase flushing of non-native predators. Flows can also affect the ability to run current trap and haul operations that support bull trout populations.

***Lake Pend Oreille and Pend Oreille River***

This region includes the Clark Fork River where it flows across the Montana-Idaho border, through Cabinet Gorge Dam and into Lake Pend Oreille; Lake Pend Oreille and any tributaries affected by lake operations or used by migratory fish from the lake; and the Pend Oreille River that flows out of Lake Pend Oreille, through Albeni Falls Dam, and downstream through the non-Federal Box Canyon and Boundary Dams, and on to the U.S.-Canada border.

Bull Trout

The Lake Pend Oreille subpopulation of bull trout is composed of migratory (fluvial and adfluvial) fish.  It is the largest-known bull trout population in Idaho. Adult and sub-adult bull trout use Lake Pend Oreille (USFWS 2010). Although considerably reduced from historical numbers, the population of bull trout in Lake Pend Oreille is considered one of the strongest populations of bull trout. Meyer et al. (2014) provided an adult population estimate of 12,513 for 2008 for Lake Pend Oreille; the population has appeared relatively steady since 1994. At least six streams where spawning has been documented are direct tributaries of Lake Pend Oreille (USFWS 2010a). This combination of productivity and wide distribution amounts to at least 15 local populations (USFWS 2015b). Redd monitoring in the 7 years following the 1999 listing suggests abundance has increased and the population is stable or increasing.

The three dams on the lower Clark Fork River (Thompson Falls, Noxon Rapids, and Cabinet Gorge) eliminated upstream migration and spawning access from Lake Pend  Oreille to 86 percent of the Clark Fork Basin, until 2001 when trap and haul programs began, substantially reducing the spawning and rearing habitat available for Pend Oreille bull trout (USFWS 2002).

No bull trout spawning has been recorded in lower Pend Oreille River tributaries downstream of Albeni Falls Dam since 2000, so there are no local populations attributed to this section of the river. It is likely any prior bull trout populations were extirpated following the construction of Albeni, Box Canyon, and Boundary Dams, which were built between 1955 and 1967 and blocked useable habitat for migratory bull trout in the river (USFWS 2002, 2008, 2010a, 2015b). Migratory bull trout from Lake Pend Oreille, entrained from the Priest River Basin or from Lake Pend Oreille (the source of bull trout between Albeni Falls Dam and Box Canyon Dam), may use the river for foraging or refuge during non-summer months. These bull trout may perish if they cannot be collected below Albeni Falls Dam and released in Lake Pend Oreille (Scholz 2005a, 2005b; Bellgraph et al. 2010).

Historically, adult bull trout have migrated out of Lake Pend Oreille, go down the Pend Oreille River, and forage in the river from October to June and then return to their tributary streams to spawn, with the progeny eventually returning to the lake (USFWS 2010). Sub-adult bull trout and non-spawning adults may remain and rear in the lake year-round (McCubbins and Hansen 2016). Each year, bull trout have potential to be entrained through the Albeni Falls Dam powerhouse or spillway and prevented from returning to spawn in lake tributaries by the lack of fish passage facilities at Albeni Falls Dam. USFWS (2018) estimated that around Albeni Falls Dam, it is likely that a maximum of 50 bull trout may be present above and 50 below at any time. Recent studies have indicated entrained adfluvial bull trout will not pioneer into tributaries below the dam and spawn (Geist et al. 2004; Scholz et al. 2005).

Conditions for bull trout habitat and migration in this reach of the study area (Figure 3-129) are controlled by lack of passage at the dams. Studies indicate bull trout study fish released downstream of Albeni Falls Dam did not survive through the summer during high water temperatures in selected years due to lack of thermal refuge (i.e., cold water habitat) below the dam (Scholz 2005; Bellgraph et al. 2010). Bull trout populations are lower than the natural carrying capacity due to impassable dams that prevent access of migratory fish to spawning and rearing areas in headwater areas of tributaries to the Pend Oreille River and Lake Pend Oreille. Fish passage and bull trout reintroduction efforts are in planning stages for this section of the Pend Oreille River. Fish passage at Box Canyon Dam below Albeni Falls Dam is set to be operational in 2020. Construction of a fish trap and haul facility at Albeni Falls Dam may be constructed during the timeframe of the CRSO analysis period. Bull trout and other salmonid species that are entrained and pass downstream through the dam likely survive at relatively high rates that can exceed 95 percent or more (Normandeau 2014).

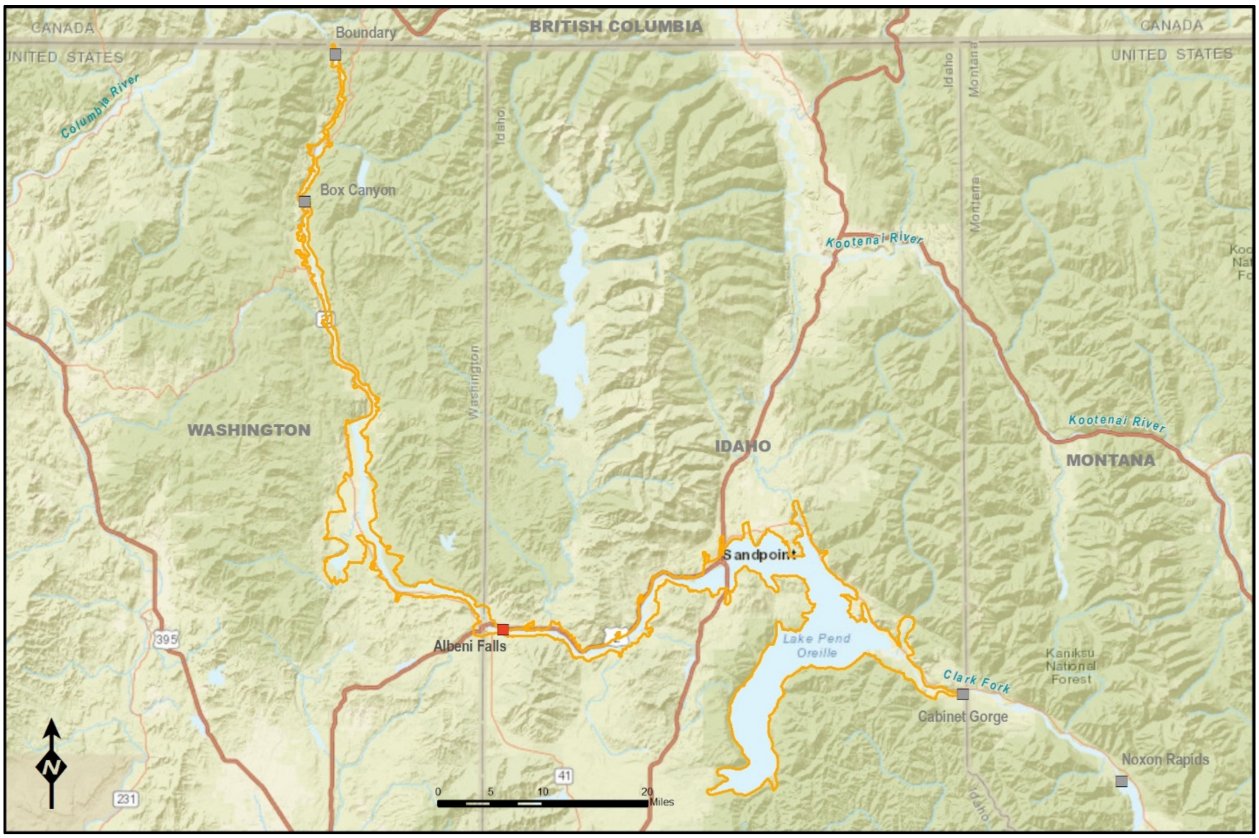



**Figure 3-129. Study Area for Lake Pend Oreille and Pend Oreille River**

Fish Communities

The Clark Fork River between Cabinet Gorge Dam and Lake Pend Oreille supports cold water and cool water sport fish. Cold water species including kokanee, rainbow trout, brown trout, and westslope cutthroat trout are common in the riverine reaches, whereas cool and warm water species such as yellow perch and largemouth bass are more abundant in the delta region of Lake Pend Oreille (FERC 2000, as cited in Corps 2006).

*Lake Pend Oreille* – Lake Pend Oreille is home to a wide diversity of catchable species such as whitefish, cutthroat and brown trout, kokanee, Gerard rainbow trout (also known as Kamloops), mackinaw or lake trout, large and smallmouth bass, crappie, pumpkinseed sunfish, perch, and bullhead (catfish). The list goes on with peamouth, northern pikeminnow, tench, suckers, sculpin, and a variety of smaller minnows contributing to the fish community. Non-native species have been introduced to Lake Pend Oreille from both legal and illegal planting of fish in lakes and rivers within the basin, including lake trout and Gerard rainbow trout, which are popular trophy fisheries. Cold water species (native and non-native) such as trout and kokanee tend to occupy the deeper waters of the lake, while warm water species such as bass, perch, crappie, and suckers (most of which are non-native, but some native species can tolerate warm water) are more prevalent in the nearshore areas and the Pend Oreille River between Sandpoint and Albeni Falls Dam. The dam provides habitat value, especially to the non-native warm water species in the summer, by decreasing velocities in the river between the lake and the dam. Conversely, available habitat for warm water species is adversely affected by the annual winter drawdown. Water velocities are typically higher and off-channel habitat more limited during winter lake elevations. Habitat with no velocity disappears as quiet bays and backwaters are dewatered. Winter drawdown of the lake interrupts spawning or egg incubation and thereby reduces numbers of non-native species like tench, largemouth bass, pumpkinseed, and black crappie compared to the population size that would exist if there were no winter drawdown (DuPont and Bennett 1993).

Kokanee are critical to the fish community in Lake Pend Oreille. Not only do they provide an important fishery for anglers, they also serve as the primary forage for predatory salmonids, including ESA-listed bull trout. In 1925, lake trout were introduced to Lake Pend Oreille. These fish expanded rapidly, competing directly with other predators for kokanee. Mysis shrimp were introduced in the 1960s to provide additional food resources for kokanee but began competing directly with kokanee for zooplankton. The combination of predation from lake trout and competition from mysis nearly caused the collapse of the kokanee population (Corsi et al. 2019). To protect bull trout, no-kill regulations were implemented, and bull trout population increased by about 6 percent annually from 1996 to 2006 (Hansen et al. 2010). To address the regional spread of lake trout, several natural resource agencies and the Kalispel Tribe of Indians used suppression as a management strategy for controlling lake trout populations (Martinez et al. 2009). Angling and netting combined have removed over 165,000 lake trout from 2006 through 2013, causing a 72 percent decline in juvenile lake trout net catches and a corresponding increase in the kokanee population (IDFG 2014). Currently, there is a tenuous balance between predator and prey in Lake Pend Oreille.

*Pend Oreille River* – In the late 1980s, native mountain whitefish, peamouth chub, northern pikeminnow, and redside shiner were the most abundant fish in the Pend Oreille River above Albeni Falls Dam (DuPont and Bennett 1993). Other native fish include cutthroat trout and suckers. The Kalispel Tribe of Indians' 2008–2012 electrofishing efforts to capture bull trout below Albeni Falls Dam provide more current information on species composition and size ranges of fish within the local area; mountain whitefish had a relatively high abundance at 14 to 33 percent, while bull trout were less than 1 percent in each year (Kalispel Tribe, unpublished data). Some of these species are lake-dwelling fish such as kokanee, lake whitefish, walleye, and lake trout. Fish species found downstream of Albeni Falls Dam are similar to those found above the dam, as fish can be passed downstream through the spillway and powerhouse.

Northern pike have become established in Box Canyon Dam Reservoir and Boundary Dam Reservoir on the Pend Oreille River where they are considered a serious threat to trout and other fish species there and throughout the region. Fish surveys conducted in the Box Canyon reservoir between 2004 and 2011 documented a rapid increase of northern pike in Box Canyon Reservoir (nearly a hundredfold increase in number of fish captured) and a decline in abundance (as much as 50 percent drop in catch rate) of forage species such as native minnows and non-native sunfish, largemouth bass, and yellow perch (WDFW 2013). As of 2018, the Kalispel Tribe of Indians is effectively reducing the population and has removed approximately 18,000 northern pike from the Pend Oreille River, nearly all of them from the reservoir behind Box Canyon Dam (NW Council 2018).

Preliminary important environmental relationships for resident fish in this region that could be affected by MOs are as follows:

- Albeni Falls Dam outflow can affect entrainment rates through the dam. Entrainment can reduce populations of native fish such as bull trout, westslope cutthroat trout, kokanee, etc., in the lake as well as hastens the spread of non-native fish from the lake into the river downstream.
- Upstream fish passage at Albeni Falls Dam may be implemented during the timeframe of the CRSO analysis period.
- Predation and competition between non-native and native fish can be influenced by operations that change outflows, temperatures, and reservoir levels.
- Flexible winter power operations result in changing lake elevations in the winter. A greater range of elevations can increase erosion rates and affect spawning success of kokanee and mountain whitefish.
- Pool elevations affect spawning habitat availability for several species.
- Albeni Falls operations affect sedimentation and erosion of lake shorelines, which could affect the availability of tributary access for bull trout, westslope cutthroat trout, and other fish that spawn in tributaries.
- Kokanee are the main food source for predatory fish such as bull trout in Lake Pend Oreille. Drawdowns after kokanee spawn can dewater eggs and reduce recruitment, however due to management guidelines the likelihood of egg dewatering is very low.
- Winter flows in the Pend Oreille River can affect spawning success of native fish.
- Water temperature in the Pend Oreille River gets too warm for many native fish such as bull trout, but once entrained, they cannot move back upstream to cooler water.

**Region B**

***Columbia River – U.S.-Canada Border to Chief Joseph Dam***

The Columbia River enters the United States and flows south into Lake Roosevelt, which is impounded by Grand Coulee Dam (Figure 3-130). Lake Roosevelt extends 151 miles (243 km) northeast almost to the U.S.-Canada border and impounds the lower reach of the Spokane River. The next segment between Grand Coulee Dam and Chief Joseph Dam is about 51 miles (82 km) of impounded pool called Rufus Woods Lake.

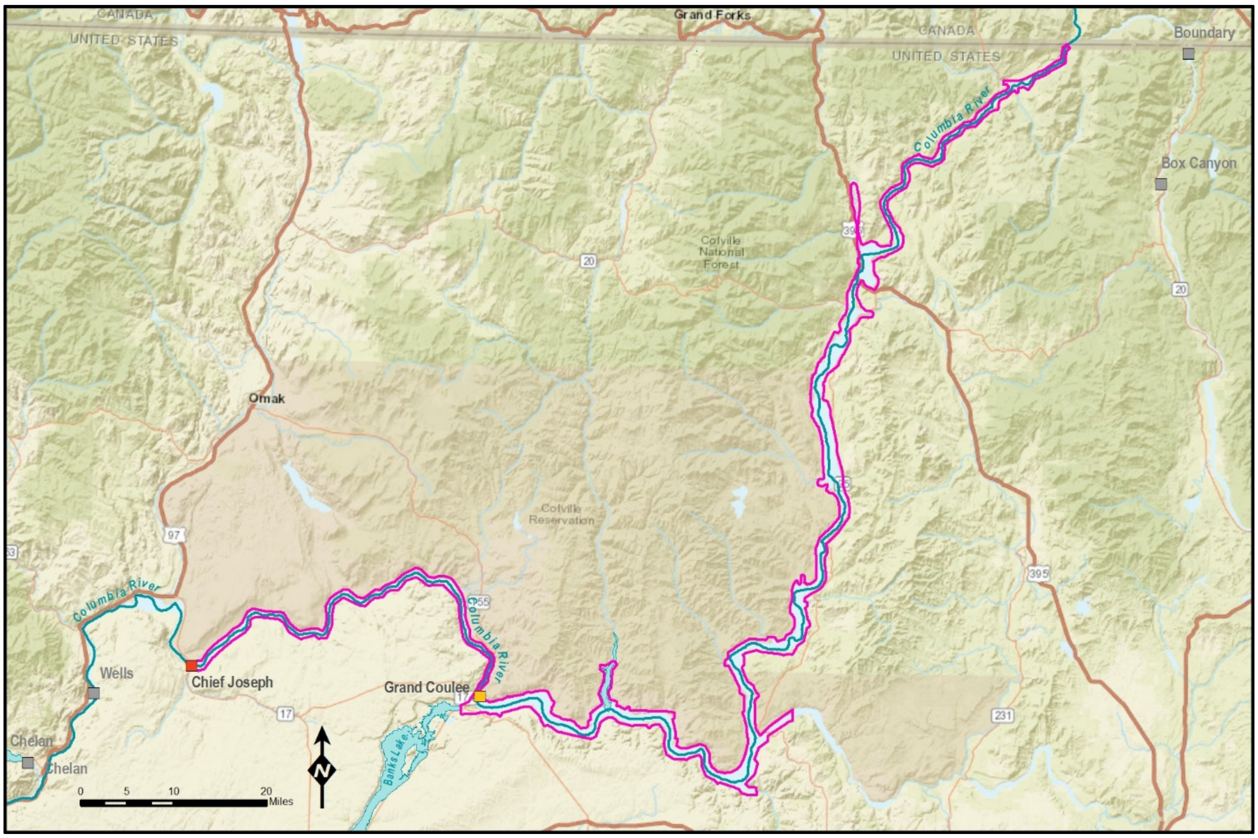



**Figure 3-130. Study Area for Columbia River (U.S.-Canada Border to Chief Joseph Dam)**

<u>Bull Trout</u>

Fluvial bull trout occur in the Grand Coulee Dam reach, this reach is classified as a research needs area (USFWS 2015). Since 2011, observations of bull trout have been increasing in Lake Roosevelt and tributaries in the northern end of the lake, typically in high-flow years (USFWS 2015). In 2012, 19 bull trout observations were reported throughout Lake Roosevelt. These fish are most likely occasional strays from populations in river systems north of the U.S.-Canada border (USFWS 2015). The Rufus Woods Lake segment includes the tailrace of Grand Coulee Dam and the Chief Joseph pool, known as Rufus Woods Lake. This segment of the project reach lies outside of designated critical habitat for bull trout, and the likelihood of bull trout occurrence in this waterbody is negligible. Bull trout accounted for less than 0.1 percent of the catch during the most recent fish inventory of the lake in 1999 (LeClaire 2000; Beeman et al. 2003). Bull trout present in Rufus Woods Lake may have been entrained through Grand Coulee Dam (Beeman et al. 2003). The Colville Confederated Tribes and the NPCC concluded bull trout use of Rufus Woods Lake was minimal (Confederated Tribes of the Colville Reservation 2000). This reach was not included in critical habitat designated in 2010 (50 CFR 17). Bull trout have been collected in the turbines at Chief Joseph Dam. It is unknown if these fish were entrained through the turbines or were migrants from the downstream populations that entered through the draft tubes.

<u>Fish Communities</u>

*Lake Roosevelt (including the Columbia River upstream to the U.S.-Canada border)* – Lake Roosevelt hosts 15 native and 12 non-native fish species. Lake Roosevelt provides a regionally and economically important sport fishery; WDFW describes Lake Roosevelt as “Washington’s biggest summertime playground” due to the robust fisheries for rainbow trout, kokanee, walleye, smallmouth bass, and burbot (WDFW 2018). Lake Roosevelt also supports an important population of native redband rainbow trout. All three life history types have also been documented within the Sanpoil River drainage, including a small fall run of lacustrine adfluvial fish (Brown et al. 2013). The Sanpoil is the only documented tributary in Lake Roosevelt supporting fall migrating adult Redband Trout (Jones and McLellan 2018).

Management of the Lake Roosevelt fishery is guided by the Lake Roosevelt Guiding Document (LRMT 2009) developed by the three co-managers (Colville Tribe, Spokane Tribe, and WDFW), with a goal to maximize recreational and subsistence harvest opportunities while minimizing adverse impacts to other native populations.

Primary harvest fisheries include rainbow trout, kokanee salmon, and walleye. The lake supports popular fisheries and fishing tournaments for trout, walleye, and bass. Other game fish include yellow perch, lake and mountain whitefish, black crappie, bullhead, sunfish, and catfish. Non-game species such as suckers, redside shiners, dace, and sculpins provide a prey base. Bull trout, westslope cutthroat trout, brook trout, and brown trout are encountered but much less frequently than the key sport fishery species in Lake Roosevelt (Underwood and Shields 1995; Cichosz et al. 1999). The non-salmonid community, once composed of lamprey, burbot, white sturgeon, suckers, and native cyprinids such as northern pikeminnow is now dominated by walleye and smallmouth bass. In addition, mountain whitefish have been displaced, though not entirely, by lake whitefish (Cichosz et al. 1999).

White sturgeon occur in Lake Roosevelt and the Columbia River upstream from the reservoir. Following the construction of the Columbia River Treaty Dams in British Columbia, Canada, and Montana approximately 40 years ago, white sturgeon in the Transboundary Reach of the Columbia River (Grand Coulee Dam to Hugh Keenleyside Dam) have experienced almost complete recruitment failure (Hildebrand and Parsley 2013). Thus, the wild population consists of a few thousand large adults. An international recovery effort was established to address the declining white sturgeon population in the upper Columbia River. Research and conservation aquaculture programs were implemented to investigate the lack of natural white sturgeon production and to restore demographics and preserve genetic diversity. These activities have determined upper Columbia River white sturgeon spawn annually at two primary locations, which occur at the confluence of the Pend Oreille and Columbia Rivers below Waneta Dam and near the town of Northport, Washington, as well as three less substantial sites near Hugh Keenleyside Dam in British Columbia, and China Bend in Lake Roosevelt. Collectively, this data suggests the recruitment bottleneck occurs at the stage when larvae are transitioning to natural foods. There are several hypotheses for the lack of natural recruitment of upper Columbia white sturgeon including habitat alteration, changes to the hydrograph, increased abundance of non-native predators, declines in food abundance, and contaminant exposure. Tens of thousands of white sturgeon larvae are captured each year in upper Lake Roosevelt, and hatchery produced fish released as yearlings survive well and are transferred to a jointly managed conservation aquaculture program. This program has experienced tremendous success, leading to the opening of tribal and recreational fisheries in 2017.

In 1986, the Lake Roosevelt Development Association began a rainbow trout net pen program to supplement the rainbow trout fishery in Lake Roosevelt (Underwood et al. 2000). Wild kokanee salmon and rainbow trout fisheries are supplemented through hatchery and net-pen operations through a multi-agency effort, the Lake Roosevelt Fishery Enhancement Program (LRFEP). LRFEP is a cooperative effort between the Spokane Tribe of Indians, Colville Confederated Tribes, WDFW, Eastern Washington University, the Lake Roosevelt Development Association (now known as the Lake Roosevelt Voluntary Net Pen Program) (Lake Roosevelt Forum 2011; Reclamation 2009). The purpose of the LRFEP is to develop a collaborative multi-agency artificial production program to provide a mitigation fishery in Lake Roosevelt. Investigations suggest the hatchery and net pen programs have enhanced the Lake Roosevelt fishery while not adversely affecting native stocks within the lake (Lake Roosevelt Forum 2011).

Habitat conditions and the resident fish assemblage of Lake Roosevelt is typical of a reservoir-based ecosystem that experiences large annual fluctuations (up to 80 ft) in reservoir levels. Many native fish species such as northern pikeminnow, suckers, chubs, native minnows, and many of the mussel species endemic to the upper Columbia River have a status of extirpated or depressed populations because of extreme habitat changes (LRMT 2009). Native fisheries such as kokanee and redband rainbow trout are sensitive to mechanisms controlled by operations such as entrainment through Grand Coulee Dam and powerplant, and effects to the food web based on water travel time through the reservoir.

The non-native and highly invasive northern pike were first observed in Lake Roosevelt in 2011. The species has been found in Kettle River (NE Washington tributary of the Columbia River) (https://www.nwcouncil.org/news/northern-pike-invade-upper-columbia-river) but has not currently been documented downstream of Lake Roosevelt. Since that time, northern pike abundance has increased and their distribution is expanding downstream. The increasing observations of northern pike in Lake Roosevelt prompted the Lake Roosevelt co-managers to implement surveys to investigate abundance, diet, growth, origin, spawning locations, and movement patterns. Aggressive removal plans are underway throughout the reservoir.

*Rufus Woods Lake* – Thirty-three species of fish occur in Rufus Woods Lake, presently or historically. The fish community includes 19 native species and 12 non-native. Non-native species include brook trout, brown trout, and rainbow trout. Native species include bridgelip sucker, sculpin, dace, and mountain whitefish (Hunner and Jones 1996). The major contributors to Rufus Woods fisheries are walleye, rainbow trout, kokanee, smallmouth bass, lake whitefish, and burbot. Mountain whitefish support mid-winter tributary fisheries. Kokanee spawn in the Nespelem River, the largest tributary of Rufus Woods Lake, while a large number of kokanee, potentially up to 30 percent of stocked fish, are entrained through Grand Coulee Dam (WDFW 2002; LeCaire and Nine 2006).

Because of the steep gradient of this reach (relative to other major rivers and reservoirs in North America) and narrow canyon morphology, much of the upper reservoir has retained more riverine characteristics than lower Columbia River reservoirs. Erickson et al. (1977) and others suggest short water retention times (1.2–4.0 days) in Rufus Woods Lake might limit plankton and fish production, and thus a major source of fish recruitment in the reservoir may be young-of-the-year fish (under 1 year old) entrained through Grand Coulee Dam. The fish community resembles a riverine more than a lake-like fish assemblage.

Entrainment through Grand Coulee Dam from Lake Roosevelt has influenced the fish assemblage in Rufus Woods Lake. Fish are most likely to be entrained during the spring freshet and winter drawdown (LeCaire and Nine 2006). The limnetic fish (i.e., fish typically found in open water away from shore) abundance and distribution compared to monthly entrainment estimates through Grand Coulee Dam (Baldwin and Polacek 2002), showed that entrainment varied seasonally; it peaked in late spring and summer then dropped off by fall (Baldwin and Polacek 2002).

A commercial net-pen rearing operation for rainbow trout exists in Rufus Woods Lake. Some of these fish escape from the net pen and some are intentionally stocked in the reservoir for a sport fishery. The rainbow trout fishery is important as a subsistence fishery for members of the Colville Tribes and a quality sport fishery for non-members. Net-pen released rainbow trout can be entrained through the dam during higher rates of spill; monitoring of individual rainbow trout shows high use areas near the forebay and in areas around the net pens (Brown et al. 2012).

High flows during late-spring/early-summer, a common spawning period for many resident fishes, may flush eggs and larvae from protected rearing areas. Periods of low water levels may reduce survival of eggs of shallow-spawning species, such as kokanee, and disrupt benthic invertebrate prey sources (Cushman 1985). In addition, water level fluctuations may affect shoreline habitat structure such as vegetation abundance.

Preliminary important environmental relationships for resident fish in this region that could be affected by MOs are as follows:

- White sturgeon recruitment success is a function of Columbia River flows at the U.S.-Canada border greater than 200 kcfs and water temperatures near 14° for three to four weeks in late June and early July, coupled with reservoir elevations low enough to provide adequate riverine habitat for adequate juvenile development prior to reaching reservoir conditions.

- Retention time in Lake Roosevelt is a very important metric for the food web interactions. Long retention times produce more plankton production that is more evenly distributed throughout the reservoir; shorter retention times can reduce productivity and also concentrate the food sources further downstream near the dam. Additionally, retention time can influence the plankton species composition and size.
- Lower retention times that concentrate food further downstream increases entrainment risk to kokanee, bull trout, redband rainbow trout and other native fish, as well as potentially increasing the entrainment of non-native predators downstream out of Lake Roosevelt.
- Outflows from Grand Coulee influence the potential entrainment rates of several species.
- Reservoir conditions favor non-native predators that affect white sturgeon, burbot, kokanee, and redband rainbow trout.
- Contaminants in the river sediments affect fish, especially sturgeon and burbot, and flows could influence the risk to these fish if they mobilize more sediment or disperse the sturgeon larvae where they are more susceptible to exposure.
- Reservoir conditions provide rearing habitat for juvenile sturgeon once they get past the larval stage and for hatchery -reared larvae, as well as burbot.
- Reservoir drawdowns in winter and early spring dewater burbot eggs, and if reservoir levels decrease in September through February kokanee eggs can be dewatered.
- Reservoir temperatures affect habitat suitability for fish; kokanee, burbot, and bull trout are particularly sensitive to warm temperatures.
- Northern pike, walleye, and smallmouth bass are non-native predators that thrive in Lake Roosevelt but can cause predation issues on native fish in the reservoir as well as downstream in the Columbia River salmon migration corridor.
- Reservoir drawdowns in spring can strand adult northern pike, but low water in spring that allows vegetated shorelines followed by higher elevations creates spawning habitat for northern pike.
- The relationships for westslope cutthroat trout and redband rainbow trout generally also apply to the resident rainbow trout mitigation fishery (except spawning issues).
- Net pens in Lake Roosevelt are susceptible to water quality (temperature, TDG, DO) at the mouth of the Spokane River.
- Reservoir elevations affect the river/reservoir interface into the Spokane arm, which can affect the rate of freezing. Lower elevations can result in earlier freezing conditions and necessitate earlier release of net pen fish than is ideal.

- Date of initiation of reservoir refill affects release date of net pen fish. Delay of refill initiation results in either fish being released earlier when they likely encounter more stressful rearing conditions due to higher temperatures and TDG or releasing fish prior to refill initiation where they are more susceptible to entrainment due to higher outflows.
- Deep drafts of reservoir elevations could limit the ability to launch boats to implement the northern pike suppression program.

### *Columbia River - Chief Joseph Dam to McNary Dam*

Below Chief Joseph Dam, the Columbia River runs for 149 miles (240 km) through a series of five narrow reservoirs impounded by run-of-river dams (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids Dams) constructed and operated by public utility districts (PUDs) (Figure 3-131). Below Priest Rapids dam there is a free-flowing stretch known as the Hanford Reach, an approximately 50-mile (80-km) section that extends into the upper portion of McNary Reservoir.

#### Bull Trout

The entire reach from Chief Joseph Dam to McNary Dam is designated as critical habitat. Major tributaries within this area with local bull trout populations include the Methow, Entiat, Wenatchee, Yakima, and Walla Walla Rivers.

Bull trout from the Methow, Entiat, Wenatchee, and Walla Walla Rivers have been documented using the Columbia River as overwintering and migratory habitat in spring, fall, and winter. Bull trout from these tributaries have been observed at Rock Island, Rocky Reach, Wells, and McNary Dams on the Columbia River. Bull trout from the Yakima River have not been found in the Columbia River.

Subadult and adult bull trout from the Methow River have been found in the Columbia River from below Rock Island Dam upstream to the Okanogan River Subbasin, while bull trout from the Entiat River have been documented at Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells Dams on the Columbia River.

Bull trout from the Walla Walla River are still fluvial and have been documented below McNary Dam and Priest Rapids Dam.

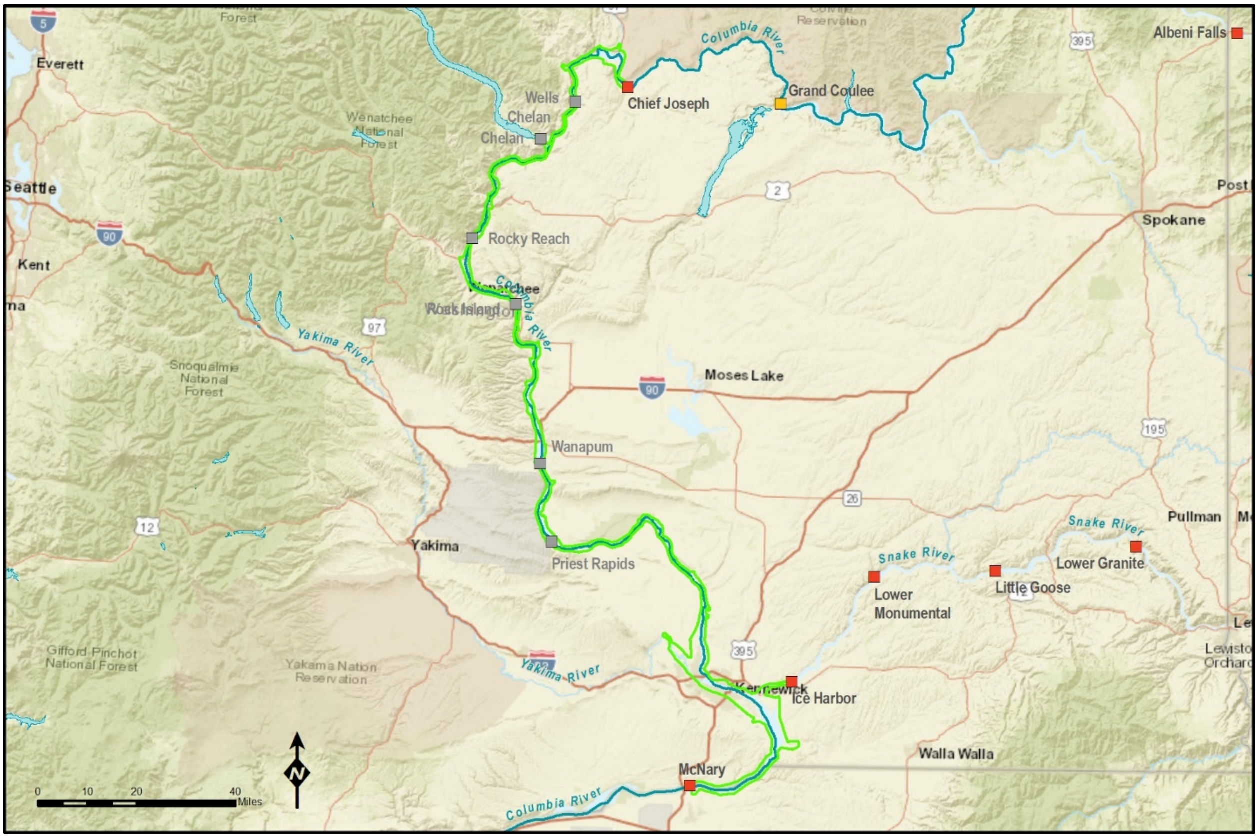



**Figure 3-131. Study Area for Columbia River – Chief Joseph Dam to McNary Dam**

<u>Fish Communities</u>

The reservoirs have relatively undeveloped shoreline and littoral zones (aquatic nearshore areas) and low water retention time. These two factors are not conducive to a high abundance of many types of resident fish. Species associated with each reservoir and the unimpounded Hanford Reach are discussed in their individual sections below.

*Wells Reservoir* – The resident fish assemblage in Wells Reservoir and downstream tailrace is composed of a diverse community of native and introduced, warm water and cold water, and recreational and non-recreational fish species. Since the construction of Wells Dam in 1967, several assessments have either directly or indirectly studied the resident fish assemblage in the Wells Reservoir (McGee 1979; Douglas County PUD 2008). These assessments have identified more than 20 species of resident fish including pumpkinseed, rainbow trout, black crappie, smallmouth bass, mountain whitefish, yellow perch, peamouth, northern pikeminnow, dace, shiners, suckers, and sculpins (See Resident fish matrix in Appendix E). The resident fish assemblage in Wells Reservoir is similar to the assemblages in nearby regions, such as Rocky Reach and Rock Island Reservoirs, and Lake Roosevelt.

*Rocky Reach and Rock Island Reservoirs* – BioAnalysts (2000) identified 41 fish species in the Rocky Reach Dam area, including cool, cold water, and warm water species. Of the species identified in this local area, 61 percent are native. The introduced species include brown trout, brook trout, lake whitefish, Atlantic salmon, pumpkinseed, walleye, yellow perch, and smallmouth bass. All warm water species in the Rocky Reach area have been introduced. Bull trout, cutthroat trout, and burbot are rare in the Rocky Reach area (Dell et al. 1975; Burley and Poe 1994; BioAnalysts 2000), and the number of white sturgeon appears to be quite low (DeVore et al. 2000). Compared to upstream reservoirs, cooler water temperatures in this local area limit production of the warm water piscivorous species including smallmouth bass and walleye, and low turbidity and poor recruitment might limit walleye production (BioAnalysts 2000).

*Priest Rapids and Wanapum Reservoirs* – Within the Priest Rapids Dam area, resident fish include a diverse mix of native and non-native species, some of which, including smallmouth bass and walleye, support important sport fisheries; 38 resident fish species occur in the Priest Rapids project area. Pfeifer et al. (2001, as cited in FERC 2006) indicate most species sampled were associated with fine substrates and shallow depths; however, some of the more abundant fish species in the Priest Rapids Dam area are successful in both river and lake habitats. Six species of native game are present in the Priest Rapids project area including rainbow trout, cutthroat trout, bull trout, lake and mountain whitefish, and burbot. Of these species, rainbow trout and mountain whitefish are common throughout the local area, while the other species are either uncommon or rare.

*Hanford Reach of the Columbia River* – The Hanford Reach extends from the base of Priest Rapids Dam (RM 393) downstream to the upper portion of McNary Reservoir (Lake Wallula) at about RM 343. The Hanford Reach is the only un-impounded section of the Columbia River in Washington above Bonneville Dam, and as such is an important refuge for native resident fish species. Extensive flow management at upstream dams has created an aquatic environment subject to substantial water level fluctuations that influence the species composition.

The Hanford Reach has 43 documented fish species, and most are resident species (Gray and Dauble 1977). Relatively common species include redside shiners, carp, largescale suckers, northern pikeminnow, peamouth, and smallmouth bass. Tench, three-spine sticklebacks, and mountain whitefish are rarely captured in Hanford Reach. Within the Hanford Reach National Monument, irrigation-fed ponds and lakes support introduced carp, bass, sunfish, and panfish (USFWS 2014).

Surveys conducted to evaluate the effects of water level fluctuation on age-0 resident fish composition, distribution, and abundance in the Hanford Reach indicated resident fish occurrence is greater in the riverine Hanford Reach compared to the more lake-like environments of the Columbia River reservoirs (Gadomski and Wagner 2009). This increased abundance could be attributed to the increased availability of spawning and rearing habitat, which might mitigate the effects of variable flow regimes.

The white sturgeon population in the Hanford Reach is intermediate in size and supports intermittent spawning, although the frequency at which juveniles reach 1 year of age has not been measured (Jager et al. 2010). Populations of white sturgeon from the lower Columbia River up to the McNary impoundment are largely genetically similar despite separation of population segments by dam construction in the 1950s and 1960s (CRITFC 2011b; Joint

Columbia River Management Staff 2012). There does appear to be some genetic influence on the mid-Columbia River populations (Bonneville Dam to McNary Reservoir) from upstream Snake River populations, potentially due to juveniles entering downstream populations (CRITFC 2011b). Harvest from 2001 to 2010 averaged 312 white sturgeon annually, and in 2010, the fishery above McNary Dam was restricted from year-round to February 1 through July 31 because of concerns for increased harvest levels (Joint Columbia River Management Staff 2012). Subsequently, harvest of white sturgeon above McNary Dam has closed indefinitely.

## Region C

### *Snake River*

The Snake River Subbasin includes the Snake River from its confluence with the Columbia River up to Hells Canyon Dam (Figure 3-132). It also includes Dworshak Reservoir and the North Fork of the Clearwater River down to its confluence with the Clearwater River, the Clearwater River down to the Snake River, and the Salmon River Basin. Within this subbasin there are five Columbia River System projects, including one storage dam, Dworshak Dam on the North Fork Clearwater River, and four run-of-river dams on the Snake River. These include Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams. All four of the lower Snake projects are equipped with fish passage facilities.

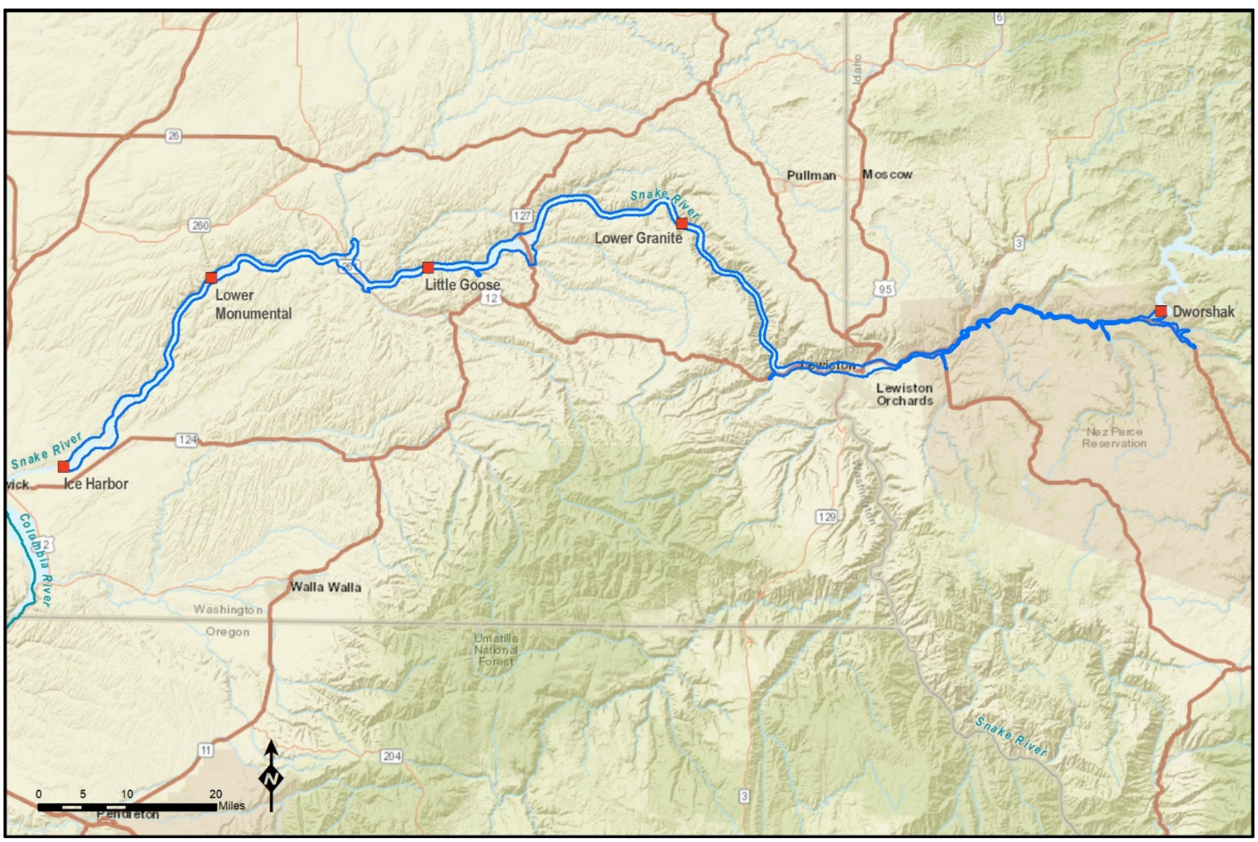



**Figure 3-132. Study Area for the Snake River**

Bull Trout

Adult bull trout that migrate between the lower Snake River reservoirs and tributaries (*adfluvial*) spend about half of every year in the lower Snake River reservoirs from November to May. These fish most likely forage in shallow areas where the majority of prey live. Depending on water conditions, bull trout will occupy deeper areas of the reservoir where water temperatures are cooler 7.2°C to 12.2°C and move to the surface when water temperatures drop to or below 12.2°C.

During recent sampling of shallow-water habitats in the lower Snake River reservoirs, single bull trout have been collected some years at a sampling site in the Lower Tucannon River (Seybold and Bennett 2010; Arntzen et al. 2012). Researchers speculated this sampling was probably not indicative of widespread bull trout use of the lower Snake River reservoirs; instead, it is potentially indicative of an adfluvial life history strategy (Seybold and Bennett 2010). During sampling and tracking of bull trout in the lower Tucannon River, bull trout have been found to enter the lower Snake River during October to January, returning to their natal streams from January to March (Bretz 2011; DeHaan and Bretz 2012).

Adult and subadult bull trout have been detected at all four of the Snake River CRS dams. Passage at these dams allows genetic exchange between the Walla Walla River, Tucannon River, Asotin Creek, Grande Ronde River, and Imnaha River Subbasins. The number of bull trout migrating to the mainstem has been quantitatively estimated in only the Tucannon, Imnaha, and Walla Walla Subbasins. Bull trout from the Tucannon River have been observed passing five mainstem dams of which three are downstream (McNary, Ice Harbor, Lower Monumental) and two are upstream (Little Goose and Lower Granite). Bull trout from the Imnaha River have been detected passing downstream through Lower Granite and Little Goose Dams and bull trout from the Walla Walla River have detected moving upstream and downstream through McNary Dam. There is limited evidence that Asotin Creek bull trout may use areas of Lower Granite Dam reservoir, and no documented evidence of bull trout from the Clearwater River entering the mainstem (Barrows et al. 2016). While Dworshak Reservoir and the North Fork Clearwater River contain healthy populations of bull trout, there is no documented evidence that these fish regularly reach the Snake River. Likewise, there is no data that bull trout from the Salmon River Subbasin use the mainstem Snake River for migratory or overwintering habitat. On the mainstem Snake River, adults tend to move back toward their headwater spawning area in the spring and summer. Bull trout from the Tucannon River Subbasin enter the mainstem Snake River from October through February and return from March through July (Barrows et al. 2016).

Bull trout spawn from August to September during periods of decreasing water temperatures. Migratory bull trout frequently begin spawning migrations as early as April and move upstream as far as 155 miles to spawning grounds. Temperature during spawning ranges from 4°C to 11°C, with redds often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989). Water temperatures exceeding 15°C limit bull trout distribution. Bull trout require spawning substrate consisting of loose, clean gravel relatively free of fine sediments.

<u>Fish Communities</u>

The Snake River Subbasin contains over 40 resident fish species (Bennett et al. 1983; Bennett et al. 1991; Mundy and Witty 1998; NPCC 2004a; Seybold and Bennett 2010; Arntzen et al. 2012; Sholz et al. 2014; Corps 2014). Eighteen of these species are native fish. Some of the more common fish in the Snake River include bridgelip sucker, smallmouth bass, walleye, peamouth, and northern pikeminnow.

The Salmon and Clearwater Rivers also provide habitat for resident fish species. Species composition is similar to those found in the mainstem Snake River, but with fewer warm water species. Resident fish common in these basins include cutthroat trout, bull trout, rainbow trout, mountain white fish, sand roller, smallmouth bass, northern pikeminnow, suckers, and in the lower Salmon Bain, sturgeon. In Dworshak Reservoir, kokanee and smallmouth bass are important fisheries.

Native cold water resident species (such as trout and whitefish), while not as common in the lower Snake River, are still abundant in the Clearwater and Salmon River Basins. Their predominance in the Snake River has been replaced by cool and warm water species (Corps 2014).

Resident fish in the lower Snake River reservoirs occupy numerous habitats and often use different habitats for different life history stages (Bennett et al. 1983; Bennett and Shrier 1986; Hjort et al. 1981; Bennett et al. 1991). Warm water species such as small and largemouth bass, crappie, bluegill, yellow perch, and carp use backwater areas for spawning and rearing (Bennett et al. 1983; Bennett and Shrier 1986; Hjort et al. 1981; Bennett et al. 1991; Zimmerman and Rasmussen 1981). Spawning and incubation times vary between species; however, most of these backwater species spawn from May through mid-July (Corps 1999b).

Juvenile fish occur in abundance in backwater and open-water areas associated with slower water velocities. Adult distribution is similar to spawning and juvenile distribution, but often varies depending on feeding strategies of the particular species. Adults may occur throughout different habitats and move seasonally or daily to different areas (Bennett et al. 1983; Bennett and Shrier 1986; Hjort et al. 1981). Although adults use a variety of habitat types, lake-dwelling species are generally more abundant in shallow, slower-velocity backwater areas, and native riverine species occur abundantly in areas with flowing water found in the tailrace zone (Hjort et al. 1981; Bennett et al. 1983; Bennett and Shrier 1986; Mullan et al. 1986). Backwater conditions created by the dams have greatly enhanced nutrient retention (Doyle et al. 2003).

During recent sampling of all four reservoirs in the lower Snake River, studies found smallmouth bass were the most common predator of the eight predatory species (northern pikeminnow, smallmouth and largemouth bass, walleye, yellow perch, white and black crappies, and channel catfish) (Seybold and Bennett 2010). Smallmouth bass were most abundant in Lower Granite

Reservoir, while northern pikeminnow were more abundant at sampling stations downstream of Lower Granite Dam. Walleye, which were caught only in the Lower Monumental and Ice Harbor Reservoirs, are now increasingly caught in Little Goose Reservoir.

Preliminary important environmental relationships for resident fish in this region that could be affected by MOs are as follows:

- Bull trout migration into and throughout the main rivers (Snake, Clearwater) for feeding, migration, and overwintering habitat can be impeded by the project facilities. Bull trout can be entrained through the Snake River dams with fish tending to move downstream more readily than upstream.
- Water temperatures in Dworshak Reservoir influence the distribution of bull trout; when further down in the reservoir, they are more susceptible to entrainment.
- Generally, warmer temperatures are correlated to higher predation risk to native fish such as bull trout, redband rainbow trout, etc., to non-native predatory fish.
- White sturgeon in the Snake River are very limited in recruitment in this region due to the limited length of riverine stretch available for larval development between projects. Most recruitment comes from upstream projects; they generally do not move upstream.
- White sturgeon and other fish can sustain physical injury from turbines if they pass through them.
- Reservoir tailraces provide a limited amount of cobble/gravel substrate for rearing habitat for the yolk-sac larvae of white sturgeon; the rest of the reservoir habitats are very limited in suitable habitat. This habitat is likely limiting sturgeon recruitment.
- Water temperatures in the lower Snake River affect all species. White sturgeon require temperatures between 8°C and 18°C.
- Outflows of Dworshak Dam influence kokanee entrainment susceptibility.
- In Dworshak Reservoir, spawning tributaries become inaccessible to spawning kokanee at an elevation below 1,450 feet in September and October.
- Run-of-river reservoir conditions in the Snake River tend to favor predatory fish such as walleye, smallmouth bass, and pikeminnow with relatively slow, deep, warm water.
- Water temperatures and flows affect the production of plankton that form the basis of the food web to support fish.

**Region D**

***Columbia River – McNary Dam to Bonneville Dam***

This region extends for 145.9 river miles from McNary Dam at RM 292.0 downstream to John Day Dam, The Dalles Dam, and finally Bonneville Dam at RM 146.1 (Figure 3-133). These projects are run-of-river dams that generate hydroelectric power and are equipped with fish passage facilities designed for salmonids. Impoundments formed by these dams include Lake Bonneville, Lake Umatilla, Lake Celilo, and Lake Wallula.

Bull Trout

Bull trout have been observed or detected moving upstream at Bonneville Dam and McNary Dam in the spring and summer (Barrows et al. 2016). The species has been observed or detected at The Dalles Dam in December and at John Day Dam from April through May.

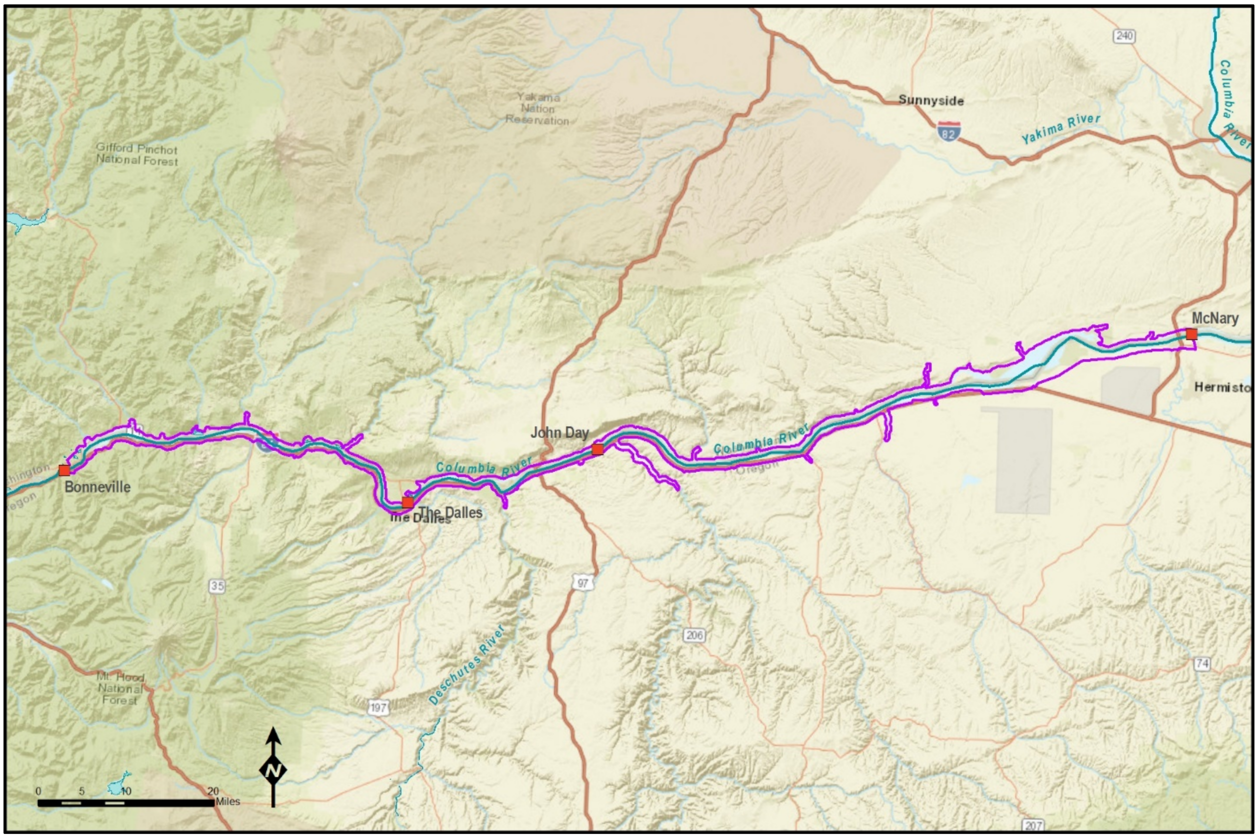



**Figure 3-133. Study Area for Columbia River – McNary Dam to Bonneville Dam**

Fish Communities

At least 45 resident fish species, of which over half are native, have been documented in the Columbia River between Bonneville and Wanapum Dams (NPPC 2001; Ward et al. 2001). Some native resident fish (e.g., white sturgeon) use reservoir habitat within this reach of the Columbia River throughout their life cycle whereas others (e.g., bull trout) live primarily in tributaries and occasionally use reservoir habitats for foraging or migration (NPPC 2001). Within this reach of the lower to middle Columbia River, the mainstem dams are barriers to upstream movements by most resident fish. However, white sturgeon (Warren and Beckman 1989) and other residents including bull trout are known to pass through fishways at the dams, although in very low numbers. The degree of entrainment of resident fish downstream through

Bonneville and The Dalles Dams is largely unknown (NPPC 2001). Resident piscivores in this reach of the Columbia River include northern pikeminnow, smallmouth bass, and walleye.

The Corps has identified legacy contamination on and around Bradford Island in the Bonneville Lock and Dam Project. The Corps has published results of sampling sediment, clams, and fish tissue. Elevated levels of PCBs were found in smallmouth bass. The Corps continues to investigate potential clean up options.

Hjort et al. sampled lower Columbia River reservoirs in 1981 for resident fish and observed several species of resident minnows. They found mountain whitefish, largescale sucker, bridgelip sucker, peamouth, and redside shiner in Lake Bonneville. Bridgelip sucker, chiselmouth, redside shiner, sand roller, longnose dace, peamouth, and largescale sucker were found in Lake Umatilla, and Lake Celilo contained longnose dace, peamouth, chiselmouth, largescale sucker, and bridgelip sucker (Hjort et al. 1981).

Preliminary important environmental relationships for resident fish in this region that could be affected by MOs are as follows:

- White sturgeon recruitment is correlated with flows greater than 250 kcfs from McNary Dam when temperatures are between 10°C and 18°C.
- White sturgeon larvae need substrate with small spaces between gravel for growth and survival of yolk-sac larvae. The magnitude and duration of high spring flows affects this habitat.
- White sturgeon and other species can be affected by high levels of TDG.
- Project facilities can impede the upstream migration of white sturgeon and bull trout that typically rely on migration and can result in isolated populations. Project configurations and operations can influence factors that increase or decrease risk.
- Bull trout and white sturgeon can migrate downstream through turbines, where they are susceptible to injury or mortality. Operations of projects can influence factors that increase or decrease risk.
- Access to thermal refugia is important to bull trout and other species.
- Fluctuations in pool elevation in the Bonneville Reservoir can suppress vegetation on the delta at the mouth of the Klickitat and Hood Rivers. This can make bull trout subject to predation when using this area.
- Reservoir conditions typically favor non-native fish such as walleye and smallmouth bass, as well as predatory pikeminnow; changes in operations, outflows, and reservoir levels can affect success of these fish.
- The presence and abundance of shad can subsidize the diets of predatory fish to increase their survival, and then when the shad are gone, the predators switch to native fish such as juvenile migrating salmonids.

***Columbia River – Below Bonneville Dam***

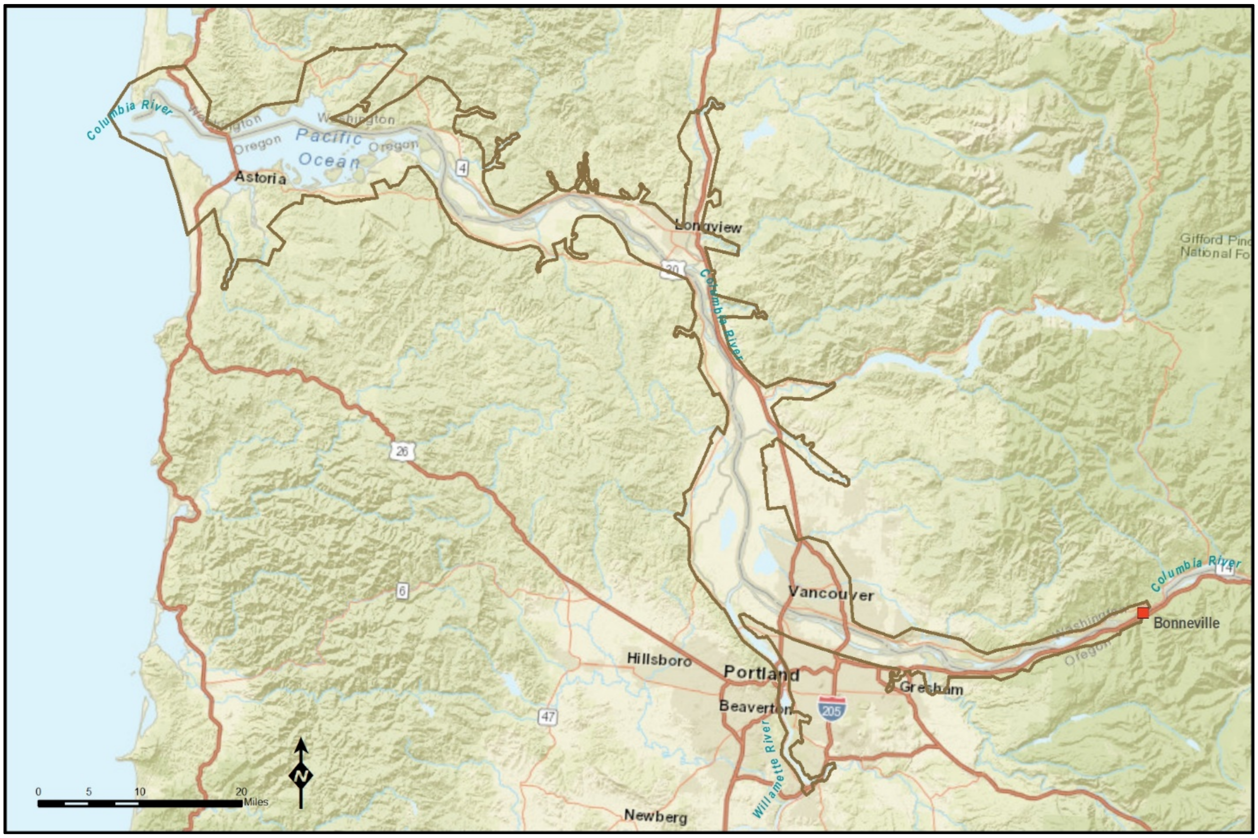



**Figure 3-134. Study Area for Columbia River – Below Bonneville Dam**

Bull Trout

Bull trout found below Bonneville Dam include fish from the Lewis, Hood, and Klickitat Rivers. The only basin that contains bull trout below Bonneville Dam is the Lewis River. Lewis River bull trout could be present in the mainstem Columbia River downstream from Bonneville Dam, but the three Lewis River dams and reservoirs restrict downstream movement and it is likely that very few individuals are able to migrate to the Columbia River.

Limited data for bull trout at Bonneville Dam and within Lake Bonneville suggest downstream movement from Hood River potentially occurs throughout the year. Bull trout intending to return to the Hood River from downstream of Bonneville Dam must pass upstream via one of several fish ladders. Only one PIT-tagged bull trout has been detected moving upstream through the fish ladders at Bonneville Dam. The detection history of this fish suggested it passed upstream through the ladder without being delayed and subsequently returned to the Hood River Subbasin.

#### *3.5.2.5 Aquatic Macroinvertebrates*

The Columbia River Basin is diverse in native aquatic macroinvertebrates. Although there is little information on the basinwide number and type of native aquatic macroinvertebrates inhabiting the study area, their importance has been well established through ecological studies. These benthic (bottom-dwelling) macroinvertebrates of river and reservoir habitats occupy habitats according to several parameters such as flow velocity, depth, temperature, and substrate types. They can serve as indicators of the overall integrity of an ecosystem and presence or absence of pollutants. Benthic organisms contribute vitally to the diets of fish, bird, and amphibian species. Freshwater aquatic macroinvertebrates provide energy transfer from detritus and algae to salmon and trout in the Columbia River Basin (Cederholm et al. 2000). Types of aquatic macroinvertebrates include insects, worms, and mollusks, and they are described in the following subsections according to whether they are native or non-native.

**NATIVE AQUATIC MACROINVERTEBRATES**

Native aquatic insects and worms are not well studied in the study area. According to BioAnalysts (2006), aquatic insect and worm taxa richness increased when more diverse habitat (e.g., vegetation, substrate) was present.

The five orders of aquatic insects most important to aquatic ecosystems in the study area are stoneflies (Plecoptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), the aquatic beetles (Coleoptera), and many species of true flies (Diptera). Many insects lay their eggs in water, with early life stages (larvae) residing primarily on or associated with the river or reservoir bottom after hatching. They are important to aquatic ecosystems because they serve as food for many species and for the roles they play in nutrient cycling and detritus processing. Aquatic insects are classified into several functional categories including shredders (e.g., giant stoneflies), scrapers (e.g., case-maker caddisflies), and collector-gathers (e.g., minnow mayflies) based on feeding habits (Cummins and Klug 1979; Merritt and Cummins 1984). Food requirements can determine aquatic insect location and abundance in the study area (Cederholm et al. 2000).

Large aquatic insects, such as caddisflies, feed on larger organic particles and inhabit cooler water, while small aquatic invertebrates, such as *Daphnia* and other zooplankton, feed on fine organic particles and inhabit slow-moving water (Rondorf, Gray, and Fiarley 1990; Cederholm et al. 2000). Aquatic macroinvertebrates are important for nutrient recycling, in part because the macroinvertebrates break down dead organic matter, such as adult salmon carcasses and non-viable salmon eggs and fry, and then serve as food for juvenile salmon and resident fish (Rondorf, Gray, and Fiarley 1990; Cederholm et al. 2000).

In reservoirs, larger, long-lived species dominate the permanently wetted zone, whereas the varial zone contains mainly small, short-lived species. Larvae recolonize previously dewatered substrates as the reservoir fills, and shoreline areas are dominated by dipterans (flies) that produce cohorts throughout the warm summer months (Chisholm et al. 1989). Zooplankton are an important food source to fish in deep reservoirs. As benthic production may be constrained by water-level fluctuations, planktonic communities can be very productive and abundant in the euphotic zone of these waterbodies.

Along the length of the rivers that have been impounded, the prey base has changed since the construction of the dams, shifting from dominance of benthic organisms to dominance of open-water zooplankton. Benthic diversity in the lower Snake River reservoirs is relatively low and is dominated by midges and worms. The density of other taxa such as amphipods (*Corophium* sp.) and nematodes is also low. Mollusk diversity is substantially lower since the impoundment of the Snake River from over 30 mollusk species to just 7 (Frest and Johannes 1992). However, crayfish appear to be well established along rock substrate and riprap in the lower Snake River reservoirs; they provide an important food source for several fish species including northern pikeminnow, white sturgeon, channel catfish, and smallmouth bass, but not for juvenile salmonids.

Native, freshwater mollusks include clams, mussels, snails, and limpets (Adams 2003). Their importance in the Columbia River Basin comes from their ecosystem functions, and some species have cultural importance as food. Freshwater mollusks filter algae, bacteria, and plankton from water, and then expel unneeded materials, which becomes food for aquatic insects (Nedeau et al. 2009). Mussels stir benthic sediments, releasing nutrients and providing habitat for insect larvae for adherence to a substrate (Nedeau et al. 2009). Mollusks are also an important food source for mammals such as otters and raccoons (Nedeau et al. 2009).

The California floater mussel (*Anodonta californiensis*) and Columbia pebblesnail (*Fluminicola fuscus*) live in the Columbia River Basin (Oregon Biodiversity Information Center 2016). Freshwater mussels, such as the California floater, are long-lived and rely on fish as an intermediate host between the larval and juvenile mussel stages (Nedeau et al. 2009). Their life histories and habitat requirements are not well-known (Nedeau et al. 2009). According to Nedeau et al. (2009), three-quarters of the freshwater mussels in North America are in danger of becoming extinct and up to 35 species are possibly extinct. California floaters can live to 100 years old and prefer clear waterbodies with soft substrate (Pacific Biodiversity Institute 2018a). The Columbia pebblesnail is short-lived and prefers clear, cold streams (Pacific Biodiversity Institute 2018b). Little is known about other freshwater mollusk species in the Columbia River Basin.

**NON-NATIVE AQUATIC MACROINVERTEBRATES**

USGS lists 52 macroinvertebrates in the Columbia River Basin and coastal waters off Oregon and Washington as non-native aquatic species (USGS 2018a). Of these species, 30 invertebrates occur in the study area including copepods, gastropods, crayfish, amphipods, isopods, and one shrimp species, to name a few. Asian clam (*Corbicula fluminea*), New Zealand mudsnail (*Potamopyrgus antipodarum*), Siberian prawn (*Exopalaemon modestus*), and the copepod (*Pseudodiaptomus forbesi*) are widespread within the Columbia River Basin (USGS 2018a). Introduced (non-native) species can occasionally become invasive if there are no natural controls on their populations such as predators, lack of food, or harsh climate conditions. Established aquatic invasive macroinvertebrates tolerate high temperatures, increased turbidity, and slow water found in Columbia River System reservoirs (USGS 2018a).

Asian clam, Chinese mitten crab (*Eriocheir sinensis*), and New Zealand mudsnail primarily affect infrastructure (USGS 2018a). Asian clams and New Zealand mudsnails can clog pipes, while Chinese mitten crabs may destabilize banks or levees (USGS 2018a). Established aquatic invasive macroinvertebrates tolerate high temperatures, increased turbidity, and slow water found in Columbia River System reservoirs (USGS 2018a).

The Japanese fishlouse (*Argulus japonicus*), Chinese mitten crab, Northern crayfish (*Faxonius virilis*), and New Zealand mudsnail are the species with the greatest potential impact to native species in the study area (USGS 2018a). Japanese fishlouse parasitize native resident fish and affect feeding and growth (USGS 2018a). New Zealand mudsnails outcompete other benthic macroinvertebrates for space and food (USGS 2018a). Chinese mitten crabs and Northern crayfish outcompete native crabs for food and space. Northern crayfish increase turbidity, which can prevent native species from thriving (USGS 2018a). Other non-native macroinvertebrate species do not appear to interact with native species.

Siberian freshwater shrimp (or prawn; *Exopalaemon modestus*) were discovered in the lower Columbia River in 1995 and have since expanded to the lower Snake River reservoirs (Emmett et al. 2002; Erhardt and Tiffan 2016). The effects of the Siberian prawn on the Columbia River System have not been fully studied yet, but this species may compete with juvenile salmon by preying on native amphipods or by providing a food source for resident fish that consume salmon such as smallmouth bass, northern pikeminnow, or walleye (Haskell et al. 2006; Sanderson et al. 2009). The Siberian prawn diet contains a large percentage of opossum shrimp (*Neomysis mercedis*), which are native to the brackish lower Columbia River and can occupy freshwater lakes and slow-moving rivers (Haskell and Stanford 2006).

The opossum shrimp range has expanded 430 miles upstream from the mouth of the Columbia to the Lower Granite Reservoir in the Snake River; within the Columbia and Snake Rivers, their abundance is limited in areas with high water velocity (Haskell and Stanford 2006; Tiffan et al. 2017). The range expansion of opossum shrimp may have aided the establishment of Siberian prawn by providing a steady food source; in addition, opossum shrimp are consumed by fish such as smallmouth bass, a predator of juvenile salmon (Erhardt and Tiffan 2016; Tiffan et al. 2017). Opossum shrimp are omnivorous, and their diet consists of several species of zooplankton and what is likely detritus (organic particulate matter) from the river bottom (Tiffan et al. 2017). Although diet overlap may create competition for zooplankton between opossum shrimp and juvenile salmon, opossum shrimp can be a prey source for juvenile salmon (Tiffan, Erhardt, and St. John 2014; Tiffan et al. 2017). More information is needed to fully describe the food web effects of opossum shrimp (Tiffan, Erhardt, and St. John 2014).

Two macroinvertebrates that are not found in the Columbia River Basin but occur in adjacent watersheds are the zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena rostriformis bugensis*) (USGS 2018a). Both species are of great concern because these species have become invasive; they clog water infrastructure pipes and grow out of control (USGS 2018a).

In 2014, the NPCC created a plan for fish and wildlife to help detect the presence of aquatic invasive species (NPCC 2014). The Council and its partners are monitoring for the presence of aquatic invasive species and are assisting with public education outreach to help educate stakeholders about the threats of aquatic invasive species to native species and aquatic ecosystems. The states of Idaho, Montana, Oregon, and, Washington have aquatic invasive species detection programs that include mandatory watercraft inspection stations located at strategic locations along or near state borders. Additionally, the states are monitoring for presence of these species and providing public education programs (Idaho.gov 2018; Montana.gov 2018; Oregon.gov. 2018; WDFW 2018).

### 3.5.3 Environmental Consequences

Operation, maintenance, and configuration of the CRS affect fish and aquatic habitat in multiple ways. Anadromous fish traveling to and from the ocean pass dams and reservoirs with passage both upstream and downstream, while resident fish may pass dams and reservoirs in their use of mainstem areas. Juvenile salmon and steelhead may pass through juvenile bypass systems, spillways, or turbines, or be collected and transported. Adult salmon and steelhead migrating upstream to their spawning grounds must use fish ladders, also called fishways. Dam operations may also alter river flows, affect water quality and temperature, create changes in reservoir elevations, affect the time it takes juvenile salmon to migrate downstream from their natal streams to the estuary (travel time). Dam operations also affect access to, and the quality of, critical and essential habitat. Section 3.2, *Hydrology and Hydraulics*, provides a detailed discussion of CRSO effects on hydrology, and Section 3.4, *Water Quality*, provides a detailed discussion of CRSO effects on water quality.

The environmental consequences analysis for anadromous fish (Section 3.5.1) is organized by species rather than by Regions A, B, C, and D in order to facilitate descriptions common to the species across specific runs throughout the Columbia Basin. The environmental consequences analysis for resident fish (Section 3.5.2) is organized by region because the effects on those species are similar in these geographic areas. With regards to potential effects in the Canadian portions of the Kootenai and Pend Oreille rivers downstream of CRS projects, the effects in this resource area under the No Action and multi-objective alternatives are expected to be similar to the effects described on those tributaries in the United States.

In both sections, effects to ESA-listed fish are generally displayed first, followed by unlisted fish. Changes to physical habitat characteristics important to fish, such as reservoir elevations, river flows, and water temperatures, are analyzed in detail in other sections (i.e., water quality [Section 3.4], hydrology and hydraulics [Section 3.2], and river mechanics [Section 3.3]) and only briefly reiterated in the fish analyses as important drivers of fish effects.

#### *3.5.3.1 Methodology*

**CONCEPTUAL ECOLOGICAL MODELS**

Conceptual ecological models (CEMs) were developed for key species to document a common understanding of the relationships between a species' needs and their environment and how controlling factors such as CRS operations can influence those environmental factors. CEMs consist of four levels:

- The species' life stages to fulfill their life cycle (i.e., eggs, larvae, juveniles, adults).
- The critical activities and processes an individual needs in order to successfully complete that life stage and move on to the next (i.e., habitat needs, food, predation avoidance, and migration).
- The environmental habitat elements that influence those critical activities and processes (i.e., water temperature, substrate, flows, nutrients, prey, and predators)
- Controlling factors that affect those habitat elements that, in turn, affect the critical activities or processes that species needs to successfully complete its life cycle.

Each of these levels is connected with a series of links (arrows) to demonstrate how controlling factors, habitat elements, critical activities and process, and life stages are related; how important that relationship is (magnitude); and how certain the scientific basis of these relationships is (link understanding). See Appendix E for more details and for CEMs developed.

**WORKSHOPS**

Multiple full day effects analysis workshops were held in Oregon, Washington, and Idaho during January through June 2019. Participants included fish experts from the three co-lead agencies as well as from many cooperating agencies. At the workshops, CEMs helped identify key relationships between the MOs and fish species, and application of those relationships at the location-specific level were discussed. Data from the water quality, hydrology/hydraulics, and other sources were then analyzed to produce quantitative or qualitative assessments of effects under the No Action Alternative and changes under the four MOs. Key relationships and how they would be affected under each alternative were recorded. This information was then used to draft the environmental consequences of the MOs. Different tools were used as appropriate to evaluate different anadromous fish species or resident communities.

**MODELS AND OTHER TOOLS TO ANALYZE EFFECTS TO ANADROMOUS FISH**

Tools available for anadromous salmonids varied by species, ESU, and DPS; the tools are described in the following sections. Salmon and steelhead ESUs and DPSs that had a basis for numerical modeling were the upper Columbia River spring Chinook salmon, upper Columbia River steelhead, Snake River spring Chinook salmon, and Snake River steelhead. Modeled outputs described below were used to evaluate the effects to these ESUs and DPSs that were numerically modeled. Other salmon and steelhead that exhibit similar migration characteristics (such as mid-Columbia and lower Columbia steelhead and salmon, sockeye salmon, and coho salmon) were evaluated using both qualitative and "surrogate" methodology where the outputs for a modeled species were used to provide insights to the effects of the other species (Table 3-60). Where an appropriate model or surrogate was not available, a qualitative evaluation of hydrology and water quality data was used to evaluate changes to the environmental factors important to the processes of the life stages, as illustrated by the CEMs. Species evaluated only qualitatively include fall-run Chinook salmon, Pacific eulachon, green sturgeon, Pacific lamprey, and American shad.

Fish models were available to predict several juvenile and adult survival metrics for upper Columbia spring Chinook salmon, upper Columbia steelhead, Snake River spring Chinook salmon, and Snake River steelhead. Where more than one model was available (i.e., both COMPASS and CSS), results from both are presented and discussed. Unless otherwise noted, quantitative results from COMPASS, CSS, and the Life Cycle Model (LCM) are based on a combination of hatchery and natural origin fish. This applies for both juvenile and adult results.

Anadromous Fish models used in this analysis and the results they produced are discussed below, and with additional detail in Appendix E. All models described below that will be used for decision-making will go through the Corps of Engineer's required Independent External Review Process.

- Comprehensive Passage Model (COMPASS) – The COMPASS model produced juvenile survival metrics for upper Columbia and Snake River ESUs of spring Chinook salmon and steelhead. COMPASS estimates passage and survival rates based on relationships that were developed using a mix of hatchery and wild fish as its data source, therefore results for this EIS analysis are based on hatchery and wild stocks combined. COMPASS breaks survival into multiple individual route of passage survivals for each reach (spill, bypass, turbine, and other configuration routes for each dam).
- National Marine Fisheries Service (NMFS) Life Cycle Model (LCM) – The LCM used COMPASS inputs to produce estimates of adult return metrics for one population of upper Columbia spring Chinook salmon (Wenatchee) and for three major population groups of Snake River spring-run Chinook salmon (South Fork Salmon, East Fork Salmon, and Upper Salmon). The results were used for comparison purposes to illustrate the response of the upper Columbia and Snake River spring-run Chinook salmon ESUs, respectively, to each of the MOs. The NMFS LCM models were developed using a combination of hatchery and wild fish data and the results presented in this EIS analysis reflect expected responses from the combined hatchery and wild components of each population/MPG.

  Similar to analyses performed during the development of the 2019 NMFS BiOp on Columbia and Snake River operations, the LCM also used a sensitivity analysis to assess potential effects of reductions in latent mortality. The purpose was to better understand to what degree the other latent effects hypotheses could affect the NWFSC life cycle modeling outputs. The additional four NWFSC scenarios were 10 percent (1.10 multiplier), 25 percent (1.25 multiplier), 50 percent (1.50 multiplier), and 100 percent (2.0 multiplier) and were applied to the ocean survival of smolts that were estimated to have migrated in river, i.e. those juveniles not collected and transported at Lower Granite, Little Goose, or Lower Monumental Dams did not receive the multiplier benefit. The results of this analysis produced estimates of changes in adult return abundance should ocean survival improve due to reduced latent mortality

- Comparative Survival Study (CSS) – The CSS cohort modeling considered all fish originating from the Snake basin and related SARs and in-river metrics. The CSS also used a Grande Ronde LCM to produce juvenile and adult metrics for the Grande Ronde/Imnaha major population group of the Snake River spring-run Chinook and steelhead. CSS models treat the entire CRS as an aggregate of two routes of passage (number of powerhouses passed vs spilled on average). CSS models make statistical estimations of the effect of the freshwater CRS on latent ocean mortality. Results were used for comparison of the Snake River spring-run Chinook and steelhead ESUs to the MOs. The CSS models were developed using a combination of hatchery and wild fish data and the results presented in this EIS analysis reflect expected responses from the combined hatchery and wild components of each population/MPG. The CSS group also produced results that were based on wild fish only at the request of the co-lead agencies. Those results were considered but did not show fundamental differences from the combined hatchery/wild estimates. Because the CSS wild only estimates still do not reflect what survival would be for wild fish in the absence of hatchery fish, and in an effort to maintain as much consistency with the data used in the LCMs, the wild only data was not reported in this chapter but it is included as a memo in Appendix E.

***Indicators and Primary Metrics***

<u>Specific juvenile- and adult-modeled metrics</u>

The following measurements are included in ESU/DPS-specific sections for upper Columbia River spring Chinook salmon, upper Columbia River steelhead, Snake River spring Chinook salmon, and Snake River steelhead, where applicable:

- Average juvenile survival.
- Average juvenile travel times.
- Proportion of juveniles originating upstream of Lower Granite Dam that are destined for transport.
- Average number of powerhouse passage events[3] for a juvenile fish passing from Lower Granite or Rock Island Dam (as applicable) to Bonneville Dam. Transported fish or fish that do not survive to Bonneville would only experience a portion of the average powerhouse passage value listed for each ESU/DPS.
- Smolt to adult return rates (SARs) are expressed as a percentage of smolts migrating downstream from one specific point and returning to a specific point as an adult.
- Estimates of adult abundance for the populations modeled. It is important to note that adult abundance models are available only for a portion of the populations, and abundance should be used as an index to compare MOs rather than actual predicted abundances.
- All fish model metrics are presented in the primary results tables as a mean without 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.

uncertainty. The 80-year water record used as input for the models represents the long-term variance in seasonal flow, temperature and other environmental variables. In the appendix, 95 percent confidence intervals and standard deviation are presented for the in-river juvenile survival metric, and 50 percent and 95 percent quantiles are presented for adult abundance for the NWFSC life cycle model.

**COMPARISON OF COMPASS AND CSS MODELS**

COMPASS and CSS are models used to evaluate the effects of the Columbia River System. They can be viewed as best available model systems developed over two decades through collaborations of universities, state and federal agencies, and stakeholders. The models both describe fish survival and migration through the system and ocean but use different processes and selections of data. COMPASS links independently calibrated system (COMPASS 2008) and ocean survival models (Scheuerell et al. 2009) and in the future other factors (personal communication, Widner and Falkner). CSS describes the entire life cycle calibrated in a single integrated statistical process (McCann et al. 2017).

The models predict different outcomes for potential system actions, such as increased spill and dam removal. COMPASS predicts small increases in returns while CSS predicts increasing spill to 125 percent TDG would roughly double the adult salmon returns. These divergent predictions are striking because both models fit smolt system passage and adult return data from the late 1990s to the present reasonably well. Thus, it is difficult to evaluate the models based on their fits to data alone. While the models apply different assumptions and predict survival with different environmental variables on different temporal scales, the divergent predictions are the result of only a few critical assumptions. The paragraphs below highlight the assumptions, identify the critical ones, and illustrate how they along with critical data shape the different predictions.

- **System survival**: The models calibrated system survival using different data. COMPASS used hydroacoustic, PIT, radio and acoustic tagged juveniles after 1990 to calibrate daily reservoir and dam survivals. The covariates explaining the survival included daily river flow, temperature, and route-specific passage through the dams. CSS used "freeze-brand" marking method prior to 1990 and PIT tag data thereafter. In addition, the CSS calibration used SAR data collected by various methods from the 1960s. The number of powerhouses (PH) that juveniles passed through and the water travel time (WTT) explained the biweekly and seasonal survival. System survivals to Bonneville Dam were similar in the two models. Thus, the differences in assumptions and data do not explain the differences in the effect of system operations on adult returns.
- **Ocean survival:** The differences in how the models link system experience to ocean mortality is the critical factor in explaining effects of system operations on adult returns. In the COMPASS model, the day of year that juvenile fish arrive at Bonneville Dam and the daily river temperature residual both affect ocean survival (Scheuerell et al. 2009). In general, later arriving fish experience lower ocean survival. In turn, ocean arrival date depends on the date fish enter the system, river flow, and passage delay at dams. Higher

flows and spill reduce WTT and delay at dams, which together promote earlier ocean arrival and higher ocean survival. Importantly, the survival-arrival date relationship is only weakly linked to spill or PH passage. In contrast, CSS links PH passage to ocean survival such that the construction of dams through the 1970s resulted in greater PH passage with successive decreases in freshwater and ocean survival. Likewise, bypassing the PH and instead passing via spillways or surface passage routes increases ocean survival. Both models include environmental variables; COMPASS includes the residual of the daily river temperature and CSS includes an index of the ocean temperature anomaly, the Pacific Decadal Oscillation (PDO), plus an index of coastal upwelling.

- **Independent Scientific Review:** Both COMPASS and CSS have been through multiple rounds and various forms of scientific peer review. The COMPASS model was published in a peer-reviewed scientific journal when it was released in 2008 (Zabel et al. 2008). Similarly, as noted above, many of the underlying drivers to the results from the CSS model(s) are based on mechanisms that were published in peer reviewed journal submissions (e.g., Haeseker et al. 2012).

In addition to these reviews, the NW Power and Conservation Council's Independent Scientific Advisory Board (ISAB) has reviewed both models over the course of their development. The ISAB reviewed the initial stages of development for the COMPASS model when it was first released in 2007 (ISAB 2007-1 and ISAB 2008-3) for use during NMFS's preparation of the 2008 Biological Opinion. The ISAB has also review each CSS annual review report since the CSS 10-year retrospective analysis was released in 2007 (ISAB/ISRP 2007-6). The ISAB has provided both technical comments and guidance for the direction of future research areas.

As noted above, highly divergent predictions of smolt to adult return rates between the CSS and COMPASS models are driven by differing approaches to latent mortality employed by the two models. These different approaches have been one of the primary focuses of ISAB reviews.

The ISAB reviews have evolved over the past decade but still have not settled on a preferred approach to attribute the cause or magnitude of the effect of latent mortality. Guidance from the ISAB has evolved from a 2007 recommendation to stop attempting to measure absolute latent mortality (ISAB 2007-1). In 2012, ISAB recommended a continuation of research efforts to assess the potential causal mechanisms of observed latent effects associated with bypass systems (ISAB 2012-1) to determine if fish were being damaged by the bypass systems or if smaller weaker fish were being passed at higher rates through the bypass systems.

In 2017 (ISAB 2017-1), as part of its review of NMFS's life cycle modeling efforts that were being developed for use in the upcoming 2019 Biological Opinion, the ISAB again reviewed components of both the COMPASS and the CSS models. The large differences in predicted smolt-to-adult returns between the two modeling approaches elicited support from the ISAB to continue research and other analytical efforts to resolve remaining questions of whether increased spill levels could increase the SARs of salmonids that migrate through the CRS. In a response to that review, two separate spill test proposals were developed by the CSS and by NMFS (ISAB 2018-2). That review was at least a partial genesis for several of the multiple objective alternatives in this EIS analysis (i.e. block spill test in MO1 and spill to the 125 percent TDG cap in MO4).

Both groups continue to develop their models to address the ISAB's ongoing questions surrounding the magnitude and the causal mechanisms associated with latent mortality through the hydrosystem. The CSS continues to analyze and report each year on patterns in overall SARs. NMFS has recently focused on the ISAB's questions on the condition of fish using the powerhouse (more specifically the bypass systems). Their most recent publication (Faulkner et al. 2019) demonstrated size selective tendencies at many of the bypass systems in the CRS which would potentially reduce the benefit of increased spillway passage shown by the CSS model. Faulkner's efforts are consistent with McMichael et al. (2010) analyzed the passage of yearling Chinook with JSATs acoustic transmitters at multiple CRS dams, and found that on average, smaller fish used the bypass routes. The CSS has also investigated this issue and found that the location where fish were collected and tagged for study is also an important component. This could be one potential reason for the discrepancies between the model outputs. As the ISAB noted in their 2017 review of the CSS (ISAB 2017-2) (closely linked to the life cycle model review [2017-1] noted above), "Modeling flow, spill, and dam breach scenarios is very useful for policy makers. Consequently, it is important that all assumptions be clearly stated and that the results are robust to these assumptions. The same scenarios should be run through both models and discrepancies resolved."

- **Summary:** The COMPASS and CSS model systems both predict the effects of hydrosystem smolt passage on adult returns of salmon. The models express the freshwater and ocean mortalities using different variables and equations linking the variables to survival and adult returns. Both models fit the available SAR reasonably well but predict very different responses of SAR to spill. The COMPASS model attributes most of the recent variations in runs to ocean conditions and predicts small effects with changes in spill. The CSS model attributes approximately two-thirds of the 50-year decline in salmon runs to powerhouse passage and predicts significant run recovery by increasing spill. The essential differences in the models involves how they express the effect of freshwater passage experience on ocean mortality.
- **University of Washington TDG model-** This model, which is separate and distinct from either the COMPASS or CSS juvenile survival models, estimated juvenile survival by reach based on reach average exposure to TDG, average juvenile fish migration depth, and exposure timing. Water that passes through the spillway at mainstem dams can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated TDG conditions can cause GBT in adult and juvenile salmonids, resulting in injury and death (Weitkamp and Katz 1980). Because this model has not been evaluated thoroughly the survival metrics predicted by this model are reported in the appendices but are not discussed in the body of this analysis and are not expected to be used as a basis for

decision-making. TDG exposure predictions are used to show relative changes in TDG amongst the alternatives.

As noted above, the similarities and differences in the two CSS models as well as COMPASS will be the subject of IEPR, the results of which will inform the final version of this EIS. The UW TDG model will also be analyzed in the IEPR process. These models are all discussed in additional detail in Appendix E.

**SURROGATES/QUALITATIVE ANALYSIS**

For some fish species, there is limited or no information on species-specific relationships for CRS dam and reservoir passage.

Consequently, how these species may respond to system changes is qualitatively assessed using modeling results from a similar species (surrogate) where similarities have been established between the species in order to assume similar impacts. Surrogate species were selected based on outmigration characteristics, life history, and timing similarities. Species with surrogates for passage effects analysis are shown in Table 3-60. The results of both COMPASS and CSS passage modeling were considered for the designated surrogate species, if available, and any key differences in passage between non-modeled and surrogate modeled species are noted. Use of species surrogates is consistent with Recovery Plans and previous ESA consultations. A more detailed description of the evaluation of surrogate data is presented in Appendix E.

**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 | *Juveniles*- Snake River spring/summer-run Chinook<br>*Adults*- Snake River fall Chinook (qualitative) |
| Upper Columbia River coho | *Juveniles*- Upper Columbia River spring-run Chinook<br>*Adults*- Columbia River fall Chinook (qualitative) |
| Snake River coho | *Juveniles*- Snake River spring/summer-run Chinook<br>*Adults*- Snake River fall Chinook (qualitative) |
| Columbia River chum | Snake River spring/summer-run Chinook |

## Resident Fish

All resident fish were evaluated during the workshops to qualitatively assess changes to the important relationships described by the CEMs and considered local knowledge of how fish species interact with their environment and one another at the fish community level. See Appendix E for the suite of CEMs developed for this EIS. Resident fish in the basin have far less quantitative information that anadromous species; no numerical predictive models were used.

Effects to resident fish were analyzed by eight subbasin teams using predicted metrics, such as water flow, elevation, temperature, and DO. Relationships between these metrics and biological metrics, as informed by the CEMs, were used to describe expected changes to habitat elements, such as productivity, the number of resident fish that are swept downstream past the dams due to flows (i.e., entrainment), and habitat losses based upon existing literature or local information. Where possible, quantitative data such as the volume of productive reservoir, percent changes in outflows, retention time, feet change in elevations, etc. were used to describe habitat effects, otherwise qualitative analyses were completed using existing literature and expert knowledge from local managers. The teams used this information to qualitatively analyze effects to fish resources. See Appendix E, Qualitative Analyses, for a more detailed description of the effects analysis and documentation methodology.

**Macroinvertebrates**

Consistent data regarding macroinvertebrate habitats and populations in the Columbia River Basin are lacking. To analyze the effects of MOs to these resources, the teams used existing literature to compare expected outcomes from the MOs using the hydrology and water quality outputs, similar to resident fish analyses.

#### *3.5.3.2 Summary of Findings from Primary Analyses of Alternatives*

Table 3-61 and Table 3-62 below provide a very high-level overview of the detailed analysis of each alternative that follows in this chapter. Quantitative estimates presented in the tables below generally represent the average result from model runs that incorporated 80 different annual river flow scenarios, each with a different volume and run-off timing component. Because the quantitative results below are not presented with any estimates of uncertainty or statistical precision (e.g. standard error, or confidence bounds) these estimates are best suited for relative comparisons of the differences between alternatives, rather than comparisons between models. It is also important to note that for any given measurement type, the CSS, and LCM models may produce results for differing river reaches.

**Table 3-61. Overview of Alternative Analysis**

| Species | NAA | MO1 | MO2 | MO3 | MO4 |
|---|---|---|---|---|---|
| **Upper Columbia Spring Chinook** | | | | | |
| Survival (%)-<br>*McNary to Bonneville* | 69.5 | 70.0 | 68.7 | 70.6 | 71.0 |
| LCM Powerhouse Passage<br>*Rock Island to Bonneville* | 3.29 | 3.08 | 3.66 | 2.89 | 2.53 |
| LCM Smolt to Adult Return Rate (%)<br>*Rock Island to Bonneville* | 0.94 | 0.95 | 0.93 | 0.95 | 0.96 |
| **Upper Columbia Steelhead** | | | | | |
| Survival (%)<br>*McNary to Bonneville* | 65.8 | 65.6 | 64.0 | 66.2 | 66.1 |
| LCM Powerhouse Passage<br>*Rock Island to Bonneville* | 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 (%) – *Lower Granite to Bonneville* | 57.6 | 58.3 | 53.7 | 68.2 | 63.5 |
| LCM Survival (%) – *Lower Granite to Bonneville* | 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 (%) – *Lower Granite to Bonneville* | 57.1 | 58.8 | 44.4 | 83.1 | 73.7 |
| LCM Survival (%) – *Lower Granite to Bonneville* | 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 |

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| 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 |

| 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<br>Hungry Horse: Minor to moderate adverse effects due to food availability, entrainment, varial zone, and river habitat.<br>Pend Oreille similar to NAA. | Kootenai: Minor adverse effects to riparian and sturgeon, minor beneficial effects to river habitat.<br>Hungry Horse: Moderate to major adverse effects due to food availability, varial zone, entrainment, and river habitat.<br>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.<br>Hungry Horse: Minor to moderate adverse effects due to food availability, entrainment, varial zone effects, and river habitats.<br>Pend Oreille similar to NAA. | Kootenai: Minor beneficial effects to riparian; minor to moderate adverse effects due to reservoir habitat and tributary access.<br>Hungry Horse: Moderate to major adverse effects due to food availability, varial zone, entrainment, and river habitat, especially in dry years.<br>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.<br>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. |

### *3.5.3.3 No Action Alternative*

**ANADROMOUS FISH**

**Salmon and Steelhead**

Several different ESUs and DPSs of salmon and steelhead share a similar life cycle and would experience similar effects under the No Action Alternative but also have specific traits that affect the units differently from one another. Common effects analyses across all salmon and steelhead are discussed first, followed by analysis of effects specific to each ESU/DPS. Note the common effects described in this section are not repeated in the species-specific sections but assumed to apply unless stated otherwise. Also, unless otherwise noted, quantitative results from COMPASS, CSS, and the Life Cycle Model (LCM) are based on a combination of hatchery and natural origin fish. This applies for both juvenile and adult results.

***Ongoing Existing Mitigation Programs***

There are numerous actions to benefit salmon and steelhead in the Columbia River Basin. Below Chief Joseph Dam, ongoing activities for anadromous fish would continue, including tributary habitat improvement actions for ESA-listed anadromous stocks, estuary habitat improvement actions for juvenile salmonids and steelhead species, and fish hatchery programs as discussed in a few examples below.

<u>Habitat</u>

Throughout Regions C and D, the Bonneville F&W Program annually funds tributary habitat improvement actions for ESA-listed anadromous stocks, such as Snake River steelhead distinct population segment, Snake River spring/summer Chinook salmon evolutionary significant unit, and the Middle Columbia steelhead distinct population segment. Examples of these habitat improvement actions include the following: fish passage and barrier removal; fish screening; instream flow acquisition; habitat protection through acquisition; river, floodplain and wetland habitat improvements; and riparian planting and fencing. For example, the Shoshone-Bannock Tribes of the Fort Hall Reservation have enhanced over five miles of the Yankee Fork Salmon River to promote anadromous and resident fish habitat.

Further, in Region D, co-lead agencies would continue to implement habitat restoration actions in the Columbia River Estuary. These actions primarily focus on the restoration of disconnected tidally influenced floodplain ecosystems for all juvenile salmonids and steelhead species in order to provide greater opportunity, access, and capacity for juvenile salmonid and steelhead rearing conditions.

<u>Hatcheries</u>

In Region B, the Confederated Tribes of the Colville Reservation operate the Chief Joseph Hatchery on the Colville Reservation below Chief Joseph Dam, releasing smolts to increase the abundance of adult summer/fall and spring Chinook to the Okanogan River and Columbia River mainstem above the Okanogan River confluence for conservation and harvest purposes, and assist in re-establishing a fourth population of upper Columbia River spring Chinook in the Okanogan River Basin through reintroduction of an experimental population under the ESA.

In Region C, Bonneville F&W Program-funded hatchery programs include the captive propagation for critically endangered Snake River sockeye, Snake River spring/summer Chinook supplementation, Snake River fall Chinook supplementation and the reconditioning of Snake River steelhead kelts. For example, the Nez Perce Tribal Hatchery produces Snake River spring/summer Chinook and Snake River fall Chinook. Further, the Springfield Hatchery, located near American Falls, Idaho, was constructed to address recovery objectives for ESA-endangered Snake River Sockeye Salmon. Dworshak National Fish Hatchery produces juvenile steelhead to mitigate for the construction of Dworshak Dam.

In Region D, Bonneville F&W Program-funded hatchery programs include coho reintroduction and supplementation in the Mid-Columbia, through hatcheries like the newly constructed Melvin R. Sampson Hatchery operated by the Yakama Nation, and reconditioning of Mid-Columbia steelhead kelts. Bonneville also funds WDFW to produce chum salmon fry in the Columbia River estuary. The Dalles and John Day Dams Mitigation Program produces fall Chinook to mitigate for the construction of the dams.

***Effects Common Across Salmon and Steelhead***

<u>Summary of Key Effects</u>

A variety of factors, including project structures, surface passage modifications, natural mortality, and predation affect juvenile migration and survival at the lower Columbia River and lower Snake River projects. Adult migration is affected by dam passage, predation, and temperature and flow conditions. The measures in the No Action Alternative are not expected to change these factors, although temperature and flow conditions may be impacted by climate change. Unless otherwise noted, quantitative results from COMPASS and the Life Cycle Model (LCM) are based on a combination of hatchery and natural origin fish. This applies for both juvenile and adult results.

<u>Juvenile Migration/Survival</u>

Juvenile salmon and steelhead can pass dam structures on the Columbia River by spillways, turbines or bypass structures. For each species of salmon, each route has an associated frequency and median survival rate. In general, bypass and spillway routes are associated with relatively higher juvenile salmon survival than turbines routes. Spill levels, spill patterns, and turbine priorities also have significant effects on the survival rates of migrating juveniles via their influence on tailrace hydraulics and the formation of eddies. As a result, alternatives that route more fish through turbines would be associated with lower juvenile survival. Currently, the majority of all juveniles pass the federal dams via spillway routes. Estimates from studies to evaluate route specific survival show that between 70 and 97 percent of all juvenile salmon pass via spillway routes. Currently, survival rates from these routes range from 97 to 99 percent (Ploskey et al. 2012). Under the No Action Alternative, these survival rates would continue.

Spill affects juvenile migration routes through the projects. Increased spill generally reduces travel time as fish find spill routes more readily than turbine routes. The forebays of dams provide habitat for reservoir predators, and the likelihood of encountering predators is increased as juvenile salmon spend more time searching for a passage entrance. Additionally, more spill generally means fewer powerhouse encounters, which would increase survival because turbines are generally associated with lower juvenile survival. Spill is not expected to change under the No Action Alternative. However, under this alternative, the co-lead agencies have incorporated expected improvements from new turbines designed for improved fish passage (IFP). Three new IFP turbines are currently being installed at Ice Harbor dam, and all turbines at McNary Dam are expected to be replaced between 2022 and 2032.

All four lower Columbia River and four lower Snake River CRS projects have available surface passage routes and/or structures in addition to 24-hour spring and summer spill programs to facilitate faster juvenile passage and higher survival. The surface passage modifications operated at the dams are generally among the highest survival routes available for juvenile salmonids, and their influence on improving spill passage efficiency and reducing forebay delay has been tested and monitored over time to meet performance criteria. Dam tailraces can increase predation risk when juvenile fish are pulled in eddies or countercurrents, and entrainment into spillway stilling basins increases the risk of injuries. Optimum tailrace hydraulics are achieved when flows are balanced among all spillway and turbine routes to achieve uniform downstream flow, which is influenced by overall discharge and spill levels. Most bypass outfalls at CRS dams have been relocated to ensure that smolts are not released into areas prone to eddies or slow velocities. Most Snake River fish pass the four lower Snake and four lower Columbia CRS projects, while the upper Columbia River fish pass up to five non-Federal middle Columbia River dams and four lower Columbia River CRS projects. Depending on model output and data availability, effects were generally evaluated for federally owned and operated projects but in some cases included passage effects associated with passage at the middle Columbia PUD projects. A variety of factors other than project structures, such as river flows, can affect the rate of downstream migration of juveniles and may affect juvenile migration and survival.

Several measures in the No Action Alternative can affect juvenile fish transportation rates, including *Storage Project Operations*, *Lower Columbia and Snake River Operations*, *Spill Operations to Improve Juvenile Passage*, and *Fish Passage Plan*, and the extent of these effects differ by fish population. The greatest effects to transport result from impacts from flows and the proportion of flow spilled. The greater the proportion of the flow that is spilled, the fewer fish available for transport. Under the No Action Alternative, approximately 39 percent of all Snake River Chinook and 40 percent of all Snake River steelhead would be destined for transport. Only Snake River species are transported.

Biological monitoring shows that the incidence of GBT in migrating smolts remains between 1 and 2 percent when TDG concentrations in the upper water column remain below 120 percent of saturation in CRS project tailraces (NMFS 2019). TDG modeling predicted that the average exposure to juveniles on their migration route for all species would be about 115 percent for the No Action Alternative. This value is relatively high, but current observations of similar values have not revealed high levels of injury or mortality for yearling Chinook salmon.

Colonial waterbirds that eat fish (i.e. piscivorous birds)—especially terns, cormorants, and gulls—are having a measurable impact on juvenile salmonid survival in the Columbia River (NMFS 2019), both as proximate and direct sources. Management efforts are ongoing toto reduce salmonid consumption by terns in the lower Columbia River, and similar efforts are in progress to reduce the nesting population of double-crested cormorants in the estuary. The Corps has been implementing the Caspian Tern and Double-crested Cormorant Management Plans. Predation rates have been reduced at the managed locations in the estuary and inland nesting sites, but due to the reduction in habitat and hazing actions, terns and cormorants have dispersed to other locations within the basin that are outside of the authority of the co-lead agencies. Moderate reductions in predation by colonial waterbirds in the Columbia River System and estuary resulting from the avian management plans are expected to continue under the No Action Alternative through the measures of *Reduce Caspian Terns on East Sand Island in the Columbia River Estuary* and *Double-crested Cormorant Management*.

Native northern pikeminnow, and non-native walleye, smallmouth bass, and channel catfish are major predators of juvenile salmonids in the Columbia River (reviewed in ISAB 2015). The Northern Pikeminnow Management Plan was initiated in 1990 to reduce predation of juvenile salmon and steelhead. Before the start of the Northern Pikeminnow Management Plan in 1990, northern pikeminnow were estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017) compared current estimates of northern pikeminnow predation rates on juvenile salmonids to before the start of the program and estimated a median reduction of 40 percent. Under the No Action Alternative, these rates are expected to continue. Additionally, non-native northern pike are present in Lake Roosevelt and, despite current suppression efforts, are likely to invade further downstream, adding another piscivorous (i.e., fish eating) predator to salmon and steelhead migration routes. Non-native walleye, smallmouth bass, channel catfish, and northern pike would continue to consume an additional unknown number of juvenile salmon and steelhead under the No Action Alternative.

Adult Migration/Survival

CRS factors that affect the survival rates of migrating adults include dam passage, where adults must find and ascend ladders and re-ascend the ladders if they fall back through spillways or other routes. Another factor is straying to non-natal tributaries either naturally or as a result of impaired homing stemming from transport, hatchery rearing (Westley et al. 2013), or other factors, such as temperature and flow conditions that can increase energetic demands of migrating fish and predation (Keefer et al. 2004; NMFS 2008a). In general, higher flows and higher spill levels lead to longer migration timing and can contribute to site specific delays for adult salmonids through the CRS projects. High water temperatures can cause migrating adult salmon to stop or delay their migration or can increase fallback after ascending fish ladders. During upstream migration, a temperature difference of more than 2°C in the fish ladders compared to river water can also delay adult migration. Under typical conditions, after accounting for harvest, adult salmonids typically have relatively high migration success through lower Columbia River and lower Snake River dams and reservoirs within the CRS (Keefer et al. 2016).

Adult migration success is not expected to change over time due to these factors under the No Action Alternative, but water temperature and flow changes expected from climate change, and their potential effects on fish species, are discussed in Chapter 4, Climate Change.

Seals and sea lions (pinnipeds) eat returning adult salmon and steelhead in the estuary and upstream to Bonneville Dam (Brown et al. 2017; Chasco et al. 2017; NMFS 2019), though occasionally some pinnipeds move up into the Bonneville pool as well. Similar to many natural fish passage impediments (e.g., waterfalls, cascades), dams or dam operations can also delay or create concentrations of adult fish searching for ladder entrances (Quinones et al. 2015), which can in turn make adult salmon and steelhead in those locations more vulnerable to predation by pinnipeds (Stansell 2004; Naughton et al. 2011). Given that the populations of Steller's and California sea lions have experienced average annual increases of 4.888 percent and 6.2 percent, respectively since the1980s, pinniped predation rates are expected to continue increasing under the No Action Alternative. However, the predation rates at Bonneville Dam can be affected through pinniped hazing and removal. Spill operations under the No Action Alternative do not appear to affect sea lion predation downstream of Bonneville Dam.

Biological monitoring shows that the current incidence of GBT in migrating adults remains between 1 to 2 percent when TDG concentrations in the upper water column remain below 120 percent TDG saturation in CRS project tailraces (NMFS 2019). GBT can reduce adult salmon and steelhead fitness and the number of fish returning to spawn. Operations under the No Action Alternative target spill levels less than 120 percent TDG through the *Spill Operations* and *Water Quality Plan for TDG and Water Temperature* measures; however, high river discharges can occasionally result in TDG levels above 120 percent.

***Upper Columbia River Salmon and Steelhead***

Upper Columbia River salmon and steelhead migrate past up to five non-Federal dams and reservoirs that also impact the survival and passage of these species. The co-lead agencies do not dictate generation or spill levels at these projects operated by the Public Utility Districts of Douglas, Chelan, and Grant counties; therefore, adult and juvenile metrics, such as powerhouse encounter rate, are not directly affected but are influenced by river flow levels coming through the upper Basin. The timing and volume of flow levels affected by CRS operational decisions are reflected in model analysis from McNary Dam to Bonneville Dam or from Rock Island Dam to Bonneville depending on model output. CSS model results are not available for upper Columbia stocks. Additional model output is presented in Appendix E.

Upper Columbia River Spring-Run Chinook Salmon

*Summary of Key Effects*

COMPASS estimates juvenile survival of upper Columbia River spring-run Chinook salmon from McNary Dam to Bonneville Dam would be 69.5 percent under the No Action Alternative. While no estimates of adult survival were generated as part of the CRSO EIS, the 10-year average survival for adult upper Columbia River spring-run Chinook salmon from Bonneville to McNary Dam is 91.5 percent. The CSS did not analyze effects of any alternative on Upper Columbia Chinook salmon so there are no results presented in this section. For context, CSS estimates of smolt-to-adult returns based on run reconstruction are provided but these estimates do not necessarily entirely reflect the No Action Alternative.

*Juvenile Migration/Survival*

The COMPASS model was used to estimate juvenile survival, travel time, for upper Columbia River spring-run Chinook salmon from McNary Dam to Bonneville Dam, and powerhouse encounters from Rock Island to Bonneville under the No Action Alternative. TDG average exposure was calculated as the level of TDG that a specific group of fish would experience as they migrate, at depth, through the system.

Under the No Action Alternative, J upper Columbia spring-run Chinook salmon survival rates from McNary Dam to Bonneville Dam under the No Action Alternative would be approximately 70 percent. By comparison, Widener et al. (2018) reported that hatchery-origin juvenile upper Columbia River spring-run Chinook salmon survival rates for this same reach of river averaged 84 percent from 2008 to 2017. TDG average exposure was calculated as the level of TDG that a specific group of fish would experience as they migrate, at depth, through the system. Table 3-63 shows TDG conditions at Bonneville, McNary, and Chief Joseph dams. Modeling also shows that these fish would be exposed to an average TDG during migration of nearly 116 percent under the No Action Alternative. This value is relatively high, but current monitoring of similar values has not revealed high levels of injury or mortality (Table 3-64).

**Table 3-63. Juvenile Model Metrics for Upper Columbia River Spring Chinook Salmon (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 |

**Table 3-64. Percent of Days with TDG above 120 Percent and 125 Percent at Bonneville, 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 |

*Adult Migration/Survival*

Upstream passage survival estimates were not generated for adult salmon. However, the historic 10-year average survival estimate for upper Columbia River spring-run Chinook salmon from Bonneville to McNary Dam is 92 percent. These survival estimates account for total losses caused by the operation and existence of the dams and reservoirs, as well as any losses in these reaches resulting from any flow effects, temperature, disease, straying, or other natural causes (NMFS 2019). Columbia Basin spring-run Chinook salmon stray rates have consistently been less than 5 percent, though some case studies have had estimates ranging to more than 20 percent (Keefer and Caudill 2012). Adult migration success is not expected to change over time due to these factors under the No Action Alternative.

The NWFSC LCM estimated that SARs for the Wenatchee upper Columbia River spring-run Chinook salmon population would be 0.94 percent under the No Action Alternative. As an index to compare the No Action Alternative to the MOs, the NWFSC LCM predicts that the median abundance of the Wenatchee population would be 498 adult fish returns.

Prospective CSS cohort and lifecycle modeling was not available across MOs for the upper Columbia salmon populations. However, though not a representation of the No Action Alternative, the CSS calculated SARs for upper Columbia populations from their reconstructions of adult and juvenile population abundance trends at about 1 percent for Wenatchee population and two percent to three percent for the Methow population (Table 3-65).

**Table 3-65. No Action Alternative Model Metrics for Adult Upper Columbia River Spring-Run Chinook Salmon**

| Metric (Model) | NAA |
|---|---|
| SARs (NWFSC LCM – RIS to BON) | 0.94 |
| NWFSC LCM abundance | 498 |

<u>Upper Columbia River Steelhead</u>

*Summary of Key Effects*

COMPASS modeling estimates that juvenile upper Columbia steelhead survival from McNary Dam to Bonneville Dam would be 65.8 percent under the No Action Alternative. While no estimates of adult survival were generated; the ten-year average survival for adult upper Columbia River steelhead migrating upstream from Bonneville Dam to McNary Dam is 92 percent.

*Juvenile Migration/Survival*

COMPASS model estimates of juvenile survival, travel time and powerhouse passage for upper Columbia River steelhead under the No Action Alternative are shown in Table 3-66. CSS modeling was not available for upper Columbia River steelhead.

The predicted juvenile upper Columbia River steelhead survival of 65.8 percent for the No Action Alternative is within the range of observed data. Widener et al. (2018) estimated that the average hatchery-origin juvenile steelhead survival rates from McNary Dam tailrace to Bonneville Dam was 74 percent for 2008 to 2017. The method of estimating survival through this area of the Columbia River has been done historically with PIT tagged fish. Low PIT tag detection efficiencies at and below Bonneville Dam have resulted in increased variability around the average survival estimate, ranging from 49 to nearly 100 percent in 2008 to 2017. Similar to results for upper Columbia spring-run Chinook salmon, modeling for upper Columbia steelhead, shows they would be exposed to an average TDG during migration of over 115 percent under the No Action Alternative. This value is relatively high, but current monitoring of similar values has not revealed high levels of injury or mortality.

**Table 3-66. Juvenile Model Metrics for Upper Columbia River Steelhead (hatchery and wild 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 |

Predation on juvenile steelhead from the Upper Columbia River has been estimated in the interior Columbia plateau at two managed sites, Goose Island (Potholes Reservoir) and Crescent Island in the mainstem Columbia River. In the Potholes Reservoir, avian predation by Caspian terns on upper Columbia River steelhead has declined from up to nearly 23 percent in 2009 to approximately 4 percent in 2017 and has been eliminated at Crescent Island since management actions commenced and loss of nesting habitat occurred in 2015 (Collis et al. 2018; Evans et al. in press; Appendix E). As the number of nesting Caspian terns were reduced at Goose Island and upstream at Crescent Island, there was an increase in abundance at Blalock Islands in the John Day reservoir. This shift in abundance has generally increased avian predation rates on juvenile steelhead in this reach, more specifically an increase in juvenile upper Columbia River steelhead predation from less than one percent to up to eight percent. Similar predation rates would be expected for upper Columbia River steelhead under the No Action Alternative.

Adult Migration/Survival

Upper Columbia steelhead would continue to experience upstream adult migration as described in Section 3.5.2.1, *Common Effects to Salmon and Steelhead*.

No life cycle modeling was completed for adult upper Columbia River steelhead. However, the 10-year average historic survival estimates for these fish, migrating upstream from Bonneville Dam to McNary Dam, is 92 percent (range of 88 to 97 percent). In addition, substantial losses (about 24 percent) of adult upper Columbia River steelhead appear to be occurring between McNary and Priest Rapids dams. These survival estimates account for total losses caused by the operations and existence of the dams and reservoirs, as well as any losses in these reaches resulting from any flow effects, temperature, disease, or other natural causes (NMFS 2019). Some of these losses may result from straying. However, most estimates of steelhead straying in the Columbia River basin have been for Snake River summer-run populations. Median straying estimates were typically between 3 to 10 percent, although some point estimates were considerably higher (Bumgarner and Dedloff 2011; Keefer and Caudill 2012). Adult migration success is not expected to change over time due to these factors under the No Action Alternative.

Downstream migration of iteroparous steelhead (i.e., steelhead that spawn more than one time, also known as kelts) occurs from March through July (Keefer et. al. 2016). Kelt migration can be affected by the extreme energetic demands of spawning and iteroparity, harvest, and the Columbia River System (Colotelo et al. 2014) and non-federal dams. Normandeau et al. (2014) conducted an direct survival adult steelhead balloon tagging study at McNary Dam and found that mean survival of steelhead passing through the temporary spillway weirs was 98 percent and 91 percent through the turbine route, for overwintering adults presumed to be in good condition. As part of a two-year study, Colotelo et al. (2013) estimated that 67 percent survived from the McNary forebay to the Bonneville Dam face. See discussion of Snake River adult steelhead for an expanded discussion of the kelt research described above.

<u>Upper Columbia River Coho Salmon</u>

See upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile upper Columbia coho salmon. Upper Columbia fall Chinook salmon analysis is considered as a qualitative surrogate for adult Upper Columbia coho salmon.

*Summary of Key Effects*

The primary challenges for upper Columbia River coho salmon are the conditions they encounter during upstream and downstream migrations. Downstream survival and migration for juveniles is dependent on water flow and routing at the dams. Higher flows and higher spills generally lead to higher survival. See Upper Columbia River spring run Chinook salmon for estimated, surrogate measures of juvenile survival.

<u>Upper Columbia River Sockeye Salmon</u>

See Upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia River sockeye salmon.

*Summary of Key Effects*

The primary challenges for upper Columbia River sockeye salmon are the conditions they encounter during upstream and downstream migrations. Downstream survival and migration for juveniles is dependent on water flow and routing at the dams. Higher flows and higher spills generally lead to higher survival.

For adults, the primary issue is high water temperatures during summer upstream migration. Upper Columbia sockeye salmon do not have significant hatchery influence so inferences would only apply to the naturally spawning population.

After passing upstream of McNary Dam, adult upper Columbia sockeye migrate past three to five PUD owned dams and reservoirs that also impact the survival and passage of this species. The federal agencies do not dictate generation or spill levels at these projects so juvenile metrics such as powerhouse encounter rate are not directly affected but are influenced by river flow levels coming through the upper Basin. The timing and volume of flow levels affected by CRS operational decisions are reflected in model analysis from McNary to Bonneville and can be referenced for surrogate species, Upper Columbia River spring Chinook salmon.

*Juvenile Migration/Survival*

Juvenile travel time affects the upper Columbia River sockeye survival during this life stage. Upper Columbia River spring-run Chinook salmon survival is used as a surrogate for upper

Columbia River sockeye. Under the No Action Alternative, juvenile sockeye are assumed to continue a similar survival rate with the same proportion of fish encountering powerhouses (e.g., the number of sockeye expected to pass through turbines and bypass systems would be similar to the number of upper Columbia River spring-run Chinook). Passage route selection in acoustic telemetry studies of upper Columbia River sockeye that were conducted by Grant County PUD support this statement (Timko et al. 2010, 2011).

River flows can affect the downstream migration rate of juvenile sockeye. Looking at the low-flow conditions (in which 75 percent of years exceed the discharge) of April 15 through June 15 when sockeye are migrating downstream, the discharge is approximately 208,000 cfs. In the No Action Alternative, the surrogate species of upper Columbia spring-run Chinook salmon may provide a conservative estimate of upper Columbia River sockeye salmon travel times. Acoustic telemetry studies have been conducted by the mid-Columbia River public utility districts and provide ancillary information, specifically Grant County PUD between 2006 and 2010, where they found that sockeye survived at a higher rate and traveled faster than yearling Chinook salmon and juvenile steelhead (Timko et al. 2011; Blue Leaf 2012). Survival of juvenile sockeye in reaches between Rock Island and McNary dams was higher in all reaches by a minimum of 5 percent and a maximum of 15 percent when compared to yearling Chinook and juvenile steelhead migrating through the same reaches with similar run timing and passage histories. Travel times by juvenile sockeye in 2006-2010 through these reaches were also faster by approximately five days, compared to those modeled in the NAA alternative of surrogate species (e.g., 15 days by upper Columbia River yearling Chinook salmon).

Juvenile sockeye are susceptible to predation by other larger fish during their downstream migration. Under the No Action Alternative, an unknown number of juvenile sockeye would be removed from the population by predators. Literature estimates that smallmouth bass, walleye, and northern pikeminnow remove large numbers of smolts. While it is difficult to measure and quantify losses of sockeye, temperature during outmigration can be used as a surrogate for estimating risk of loss to predators. The mean water temperature from April 15 through May 31 at McNary Dam is 1200°C under the No Action Alternative and can be used for comparisons of qualitative increases or decreases in predation risk for the MOs in relation to the No Action Alternative.

Avian predation on juvenile salmon is another important factor of surviving their outmigration. Predation rates on juvenile upper Columbia River sockeye are not well documented; however, since 2010, predation rates by the Caspian tern nesting colony at the Blalock Islands Complex on Snake River sockeye has averaged one percent (Evans et al. in press). Nesting habitat and avian predation rates would remain the same under the No Action Alternative and therefore predation rates should remain similar (one percent or less).

TDG during the migration period can affect juvenile and adult sockeye in the form of GBT; the condition is more stressful for juvenile fish, which are more susceptible because they tend to swim at shallower mean depths (Backman and Evans 2002). The No Action Alternative is expected to continue at the same rate as presently occurs each year and similar to the surrogate species, upper Columbia River spring-run Chinook salmon.

*Adult Migration/Survival*

See the Effects Common across Salmon and Steelhead section (Section 3.5.2.4), for an overview of adult migration/survival effects on salmon and steelhead under the No Action Alternative.

Higher water temperatures correspond to lower adult survival during upstream migration and survival can be less than 50 percent when water temperature is greater than 18°C. When the Okanogan River gets to 21° to 22°C, fish stop moving into the river; survival then depends on temperatures in the Columbia River where they hold in refuge. The migration period is early June through mid-August; therefore, the important metric is the percentage of days the daily mean temperature exceeds 18°C at McNary and Chief Joseph Dams. Recent data shows McNary Dam has 72.4 percent of days in this period above 18°C and Chief Joseph Dam has 24.9 percent of days above 18°C. These conditions are expected to continue under the No Action Alternative and have adverse effects to the species when present. Survival is expected to continue to be less than 50 percent during years that are warmer than average.

<u>Upper Columbia River Summer/Fall-Run Chinook Salmon</u>

*Summary of Key Effects*

Key effects to upper Columbia summer/fall-run Chinook salmon include high predation rates of juvenile fish and elevated water temperatures during adult upstream migration. An estimated 50 percent of all juvenile Chinook salmon do not survive from Priest Rapids Dam to McNary Dam (Harnish et al. 2014). These fish are lost through predation by birds or other fish. In addition, elevated water temperatures can delay adult migration. Water temperatures currently reach over 68°F approximately 1 in 3 days during the summer/fall migration.

*Larval Development/Juvenile Rearing*

Adequate spawning habitat is limited in the Columbia River. The Vernita Bar, located downstream of Priest Rapids Dam, is a critical spawning site for upper Columbia summer/fall-run Chinook salmon in the Columbia River. Water level management is important for spawning in this reach and can have adverse effects if water levels are dropped by desiccating eggs or stranding fry. An agreement called the Vernita Bar Agreement was reached in 2004 and maintains a minimum outflow of 70,000 cfs to guarantee adequate spawning habitat for Chinook salmon below Priest Rapids Dam during spawning and incubation. To evaluate effects to spawning habitat, investigators calculated the frequency of meeting the Vernita Bar Agreement. Under the No Action Alternative, the agreement is met in all years.

Water quality is important for egg and fry incubation and development. Specifically, water temperatures over 68°F and TDG over 120 percent were selected as metrics to evaluate adverse effects to early life stages of Chinook salmon. The frequency of days that exceeded these values were used to evaluate effects. Under the No Action Alternative, no days were projected with values for temperature or TDG would exceed critical levels.

*Juvenile Migration/Survival*

Compared with yearling Chinook and steelhead, subyearling fall Chinook typically migrate deeper in the water column and are less likely to use surface spillway routes. An estimated 50 percent of juvenile upper Columbia summer/fall-run Chinook salmon are lost before they reach McNary Dam to birds or other predators (Harnish et al. 2014). Water temperature can affect juvenile salmon survival via predation. As temperatures increase, aquatic predators become more active and metabolic demands increase. Consequently, risk to predation for juvenile salmon increases. To analyze potential effects of MOs, an increase or decrease in water temperatures during migration was used as a surrogate for predation risk. To measure effects to predation risk, the number or percent of days, May through August, with mean temperatures over 20°C was used to compare MOs. Currently, water temperatures exceed 20°C approximately 42 percent of the time. These water temperatures would impact juvenile Chinook salmon survival through the mechanisms listed above; however, it is unknown what total number of these fish are lost to predation. The No Action Alternative is expected to continue the existing conditions.

Avian predation on juvenile salmon is another important factor impacting their surviving during outmigration. Snake River fall-run Chinook salmon predation rates from avian predators at East Sand Island ranged from 0.7 to 3.4 percent for Caspian terns and from 1.6 to 8.7 percent for Double Crested Cormorants (Evans et al. 2018). Similar rates of predation are expected for upper Columbia River summer/fall-run Chinook salmon. Nesting habitat for birds would remain the same under the No Action Alternative.

During juvenile outmigration, instances of higher turbidity can decrease predation rates because reduced clarity of water hides juveniles so their susceptibility to predation decreases. The No Action Alternative is expected to have no changes to timing and duration of higher turbidity.

*Adult Migration/Survival*

The frequency that water temperatures at McNary Dam exceeded 20°C July through November was used as a measure of potential migration delay for upper Columbia River summer/fall-run Chinook salmon. In the No Action Alternative, over 34 percent of days between July and November would be over 20°C. Most of these days occur in July and August. Adult summer run Chinook typically migrate from the start of June through early August, and the tail end of the run may continue to be affected by elevated temperatures in late July and August. The start of the fall Chinook migration typically starts in August when temperatures still exceed 20°C, and peaks in September when temperatures decline.

During upstream migration, a temperature difference of more than 2°C in the fish ladders compared to river water can delay adult migration. Water temperature differentials at the fish ladders are most concerning June through September when elevated temperatures are most likely to create differences that may lead to adult migration delays. At McNary Dam, less than 3 percent of days from June through September would have ladder differentials greater than 2°C. Under the No Action Alternative, these limited events are expected to continue.

Other water quality parameters include sediment levels measured in total suspended solids and DO concentrations. Both parameters are measured in milligrams per liter (mg/L). The average sediment concentrations in current conditions are approximately 2 mg/L and no change is anticipated in the No Action Alternative. The typical DO concentrations in the Snake River are between 9.5 and 11 mg/L, which poses no trouble for fish species. Under the No Action Alternative, no adverse effects are expected from the oxygen concentrations.

***Middle Columbia River Salmon and Steelhead***

<u>Middle Columbia River Spring Chinook Salmon</u>

See quantitative results from the Upper Columbia River Spring Chinook analysis as a surrogate for Middle Columbia River Spring Chinook Salmon.

*Summary of Key Effects*

Middle Columbia River spring Chinook salmon are not ESA-listed and limited migration/survival data exists. The primary challenges for middle Columbia River spring Chinook salmon are the conditions they encounter during upstream and downstream migrations. Downstream survival and migration for juveniles is dependent on water flow and routing at the dams. Higher flows and higher spills generally lead to higher survival. See Upper Columbia River spring Chinook salmon for estimated, surrogate measures of juvenile survival. Middle Columbia River spring Chinook salmon would experience similar survival rates, although they traverse a shorter distance than their upper Columbia River counterparts, they pass the same dams from McNary to Bonneville Dam and their juvenile and adult migration timing and survival would be similar.

<u>Middle Columbia River Steelhead</u>

Refer to upper Columbia River steelhead analysis as a surrogate for middle Columbia River steelhead.

*Summary of Key Effects*

Key effects for middle Columbia River steelhead include delays during upstream adult migration from elevated water temperature and reduced survival during downstream migration, similar to the results of surrogate species, upper Columbia River steelhead.

*Juvenile Migration/Survival*

Middle Columbia River steelhead would experience similar survival rates under the No Action Alternative. Although middle Columbia River steelhead traverse a shorter distance than their surrogate, upper Columbia River steelhead, they pass the same federal dams from McNary Dam to Bonneville Dam. Because effects to middle Columbia River steelhead were not modeled, upper Columbia River steelhead were used as a surrogate species to evaluate effects of MOs on middle Columbia

Predation on juvenile steelhead from the middle Columbia River has not been estimated in the interior Columbia plateau; however, predation rates would be similar to upper Columbia River steelhead under the No Action Alternative. Refer to the results of Upper Columbia Steelhead as a surrogate for Middle Columbia River Steelhead.

*Adult Migration/Survival*

No smolt to adult return rates were calculated for upper or middle Columbia River steelhead. Refer to the results of Upper Columbia Steelhead as a surrogate for Middle Columbia River Steelhead.

Each summer, when the mainstem Columbia River temperature increases to above 18°C, a large portion of middle Columbia River steelhead seek cool water temperature refuge in cooler tributaries such as the Little White Salmon, White Salmon, or Deschutes Rivers, or in deeper/cooler mainstem areas within the Columbia River. In July and August, during the peak of the middle Columbia River steelhead adult migration, the sun warms the water in the top portion of the reservoirs, which can lead to high temperatures and water temperature differences in the fish ladders. Ladder temperatures exceeding 20°C and water temperature differences greater than 1.8 degrees Fahrenheit have been demonstrated to cause delay in steelhead and can reduce their successful migration to the streams in which they were born (Caudill et al. 2013). Ladder temperatures commonly exceed 20°C and ladder differentials regularly exceed 1.8 degrees Fahrenheit while middle Columbia River steelhead are migrating (McCann 2018). During the most extreme summer days, ladder temperatures in CRS dams can exceed 75.0°F, and ladder differentials can exceed 4.5 degrees Fahrenheit (FPC 2019). This would continue under the No Action Alternative.

A proportion of middle Columbia River steelhead from the John Day major population group (MPG) do not enter the John Day River in the summer, likely because of elevated water temperatures. Based on PIT detections, many of these fish migrate past the John Day River in the summer and overshoot McNary Dam, presumably to find cooler water until the John Day River cools. A large portion of these fish do not attempt to migrate back downstream through McNary Dam until after prescribed spill has ended in August, and a smaller portion do not attempt downstream migration until after the juvenile bypass system has shut down in mid-November. Some of these fish overwinter in the McNary Reservoir or further upstream. This leaves the turbines as the only available passage route for many of these fish, which is the lowest survival route for adult steelhead. Research conducted since the implementation of the 2008 FCRPS Biological Opinion has demonstrated the spillway weir is the most effective and safe route to pass adult steelhead at McNary Dam. Normandeau et al. (2014) conducted an adult steelhead balloon tagging study at McNary Dam and found that 98.0 percent of the steelhead passing the temporary spillway weir survived and were injury-free. The fish passed through the turbine unit had significantly lower survival (91 percent) and more life-threatening injuries, presumably caused by blade strike and shear forces. Colotelo et al. (2013) also found that the survival of adult steelhead kelts through spillways and surface weirs was high (>95 percent), and survival through turbine units was lower (<80 percent), indicating that overshoots survive at a higher rate when spill protection is provided when they migrate back downstream.

Downstream migration of iteroparous steelhead (i.e. steelhead that spawn more than one time, also known as kelts) occurs from March through July (Keefer et. al, 2016). Kelt migration can be affected by the extreme energetic demands of spawning and iteroparity, harvest, and the Columbia River System (Colotelo et al. 2014) and non-federal dams. Normandeau et al. (2014) conducted an direct survival adult steelhead balloon tagging study at McNary Dam and found that mean survival of steelhead passing through the temporary spillway weirs was 98 percent and 91 percent through the turbine route, for overwintering adults presumed to be in good condition. As part of a two-year study, Colotelo et al. (2013) estimated that 67 percent survived from the McNary forebay to the Bonneville Dam face.

Predation effects to summer migrating adult middle Columbia River steelhead are likely relatively small because pinniped numbers are generally low in July and August, when most middle Columbia River steelhead pass Bonneville Dam, and the steelhead are mixed with relatively abundant fall-run Chinook salmon migrating in September and October.

#### ***Snake River Salmon and Steelhead***

<u>Snake River Spring/Summer-Run Chinook Salmon</u>

*Summary of Key Effects*

COMPASS and CSS modeling estimates of juvenile Snake River spring/summer-run Chinook salmon survival range from 50.4 to 57.6 percent, respectively, with substantially different estimates for the number of Snake River spring/summer-run Chinook salmon that would be transported. The two models also predict significantly different smolt-to-adult return rates.

*Juvenile Migration/Survival*

COMPASS and CSS cohort models both provide estimates of juvenile survival metrics (Table 3-67). Results below reflect combined natural and hatchery origin juvenile Snake River spring/summer Chinook salmon in-river survival. It is important to note that hatchery Snake River spring-run Chinook salmon have about 15 percent higher in-river survival rate than natural origin Snake River spring-run Chinook, but Snake River summer-run Chinook salmon for both hatchery and natural origin juveniles have similar in-river survival rates (Buchanan et al. 2010). The COMPASS and CSS cohort model estimates are reported as the average value based on the 80-year water record estimates for both hatchery and natural origin fish. The values are provided below, but these metrics are best used for relative comparison purposes between MOs.

**Table 3-67. Juvenile Model Metrics for Snake River Spring/Summer Chinook Salmon (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% |

All Estimates are from Lower Granite Dam to Bonneville Dam.

For comparison with historic survival rates, Widener et al. (2018) estimated that juvenile Snake River spring-run/summer Chinook salmon survival rates (wild and hatchery combined) from Lower Granite to Bonneville Dam averaged 53 percent (ranging from 44 to 64 percent) for the same time period. These survival rates incorporate multiple sources of mortality such as passage mortality, natural mortality, and predation (NMFS 2019).

Juvenile fish transportation is also a factor in returning adult conversion rate as fish pass back up through the CRS years later, though other factors such as temperature, spill, and catch are more important to upstream system survival (Crozier et al. 2016). Overall, transported Snake River spring/summer-run Chinook salmon tend to have relatively low rates of straying (Gosselin et al. 2018).

Wild yearling Chinook salmon tend to have the lowest transport benefit, and hatchery yearling Chinook salmon and hatchery steelhead tend to have higher benefits from transport. In addition, fish transported later in the year generally show greater benefits from being transported late and to transporting hatchery fish. For the No Action Alternative, CSS cohort modeling predicts a season-wide Transport:In-River benefit ratio for natural origin yearling Chinook salmon of 0.86 for comparison with alternatives. However, season wide TIR ratios can be misleading as benefits of transport vary within season. For example, in most years, beginning in May, adult returns are higher for transported spring summer Chinook than for in river fish (Smith et al. 2013).

*Adult Migration/Survival*

See the Effects Common across Salmon and Steelhead section, Section 3.5.2.2, No Action Alternative, for an overview of adult migration/survival effects on salmon and steelhead under the No Action Alternative.

The 10-year average (2008 to 2017) minimum survival estimate for hatchery and natural origin Snake River spring/summer-run Chinook salmon from Bonneville to McNary Dam is 89 percent, with range of 83 to 100 percent, and from Bonneville to Lower Granite Dam is 84 percent, with range of 77 to 94 percent (NMFS 2019). These survival estimates account for total losses from the dams and reservoirs, as well as any losses in these reaches resulting from any flow effects, temperature, disease, or other natural causes (NMFS 2019).

Columbia Basin spring-run Chinook salmon stray rates have consistently been less than 5 percent, though some case studies have had estimates ranging to more than 20 percent (Keefer and Caudill 2012). Adult migration success is not expected to change over time due to these factors under the No Action Alternative.

For Snake River spring/summer-run Chinook salmon specifically, seal and sea lion presence in the Columbia River appears to coincide with salmon upstream migration timing (Tidwell et al. 2017). While pinniped injury to some degree adversely affects conversion to spawning tributaries, pinniped-caused injury rates decrease as annual run sizes increase, indicating density dependent or saturation effects in some years (Naughton et al. 2011). Pinniped predation rates are expected to continue to increase under the No Action Alternative.

Under the No Action Alternative, SARs for Snake River spring/summer-run Chinook salmon were estimated at 0.88 and 2.00 for NMFS and the Fish Passage Center models, respectively (Table 3-68). These numbers are similar to values observed in recent years for this species. Overall Lower Granite to Bonneville SARs for wild Snake River Chinook with jacks included have ranged from 0.30 to 4.13 (arithmetic mean of 1.32 percent) between 2000-2016 (Table B.2, 2018 Final CSS Report).

**Table 3-68. Model Metrics Related to Adult Survival and Abundance of Snake River 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 |

1/ CSS provided results for six populations in the Grande Ronde/Imnaha Major Population Group. The absolute values represent those populations only.

Snake River Steelhead

*Summary of Key Effects*

Modeled estimate of in-river survival is near the recent observed survival rates of juvenile Snake River steelhead between Lower Granite Dam and Bonneville Dam, which were estimated on average at 56 percent from 2008 to 2017. Over the same period, the average upstream survival for these adult fish from Bonneville Dam to McNary Dam was 94 percent, and survival from Bonneville Dam to Lower Granite Dam was 87 percent. Juvenile transport continues to show an overall benefit for Snake River steelhead. However, the degree of benefit has decreased as in-river survival has increased. Additionally, the proportion of fish being transported has steadily declined since 2008.

*Juvenile Migration/Survival*

Survival of juvenile Snake River steelhead from Lower Granite to Bonneville Dam is estimated at 42.7 and 57.1 percent for COMPASS and CSS modeling, respectively (Table 3-69). By comparison, Widener et al. (2018) estimated historic juvenile Snake River steelhead survival rates (wild and hatchery combined) from 2008 to 2017 for this same reach at 56 percent. These survival rates incorporate multiple sources of mortality, such as passage mortality, natural mortality, and predation (NMFS 2019).

**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 |

The effectiveness of the juvenile fish transportation program is evaluated annually, and juvenile transport continues to show an overall benefit for Snake River steelhead. However, the degree of benefit has decreased as in-river survival has increased and the proportion of fish being transported has decreased subsequent to the increase in spill and the later transport collection dates that were implemented for juvenile yearling spring-run Chinook salmon and steelhead in 2006 (NMFS 2019). The experience of transportation as juveniles is a factor influencing conversion rate of returning adults as fish pass back up through the CRS years later, especially for natural origin steelhead (Keefer et al. 2008). Recent transport rates (2008 to 2017) have averaged 34 and 32 percent for wild and hatchery Snake River steelhead, respectively (NMFS 2019). For No Action Alternative modeling, the transportation start date was April 25 under the *Juvenile Fish Transportation in the Columbia and Snake Rivers* measure. CSS cohort modeling estimated the average season-wide transport to in-river SAR ratio (TIR) for Snake River steelhead at 1.41 for comparison to MOs, based on both hatchery and natural origin fish. However, season wide TIR values can be misleading as the benefits of transport vary within season, where fish transported later in the year generally show greater benefits from being transported.

*Adult Migration/Survival*

The historic 10-year average (2008 to 2017) minimum survival estimate for Snake River steelhead adults from Bonneville Dam to McNary Dam was 94 percent, with range of 90 to 100 percent, and the minimum survival estimate from Bonneville Dam to Lower Granite Dam was 87 percent, with range of 81 to 94 percent (NMFS 2019). Most estimates of steelhead straying in the Columbia River basin have been for Snake River summer-run populations. Median straying estimates for Snake River steelhead are typically between 3 to 10 percent, although some point estimates were considerably higher (Bumgarner and Dedloff 2011; Keefer and Caudill 2012). Adult migration success is not expected to change over time under the No Action Alternative, but Chapter 4 discusses anticipated effects of climate change.

For Snake River steelhead specifically, Steller sea lions in particular aggregate at the base of Bonneville Dam in the fall when Snake River steelhead are present. Adjusted consumption estimates for all steelhead at the tailrace of Bonneville Dam by pinnipeds is 1.5 percent (Tidwell et al. 2018). Based on the timing of the observations in the study, NMFS (2019) stated that 1.5 percent is a reasonable estimate for Snake River steelhead mortality due to pinnipeds.

Migration of iteroparous steelhead (kelts) occurs from March through July (Keefer et. al, 2016). Migration success rates from Lower Granite Dam to downstream of Bonneville Dam was estimated at 4.1 and 15.6 percent in 2001 and 2002, respectively (Wertheimer and Evans, 2005). These estimates represent total mortality to outmigrating kelts and were derived in a low flow year with very little spill (2001) and a more normal flow year with spill (2012). In 2013, Colotelo et al. (2014) estimated that 27 percent of kelt migrated successfully from Lower Granite Dam to below Bonneville Dam. The majority of kelts utilized spillways and surface flow outlets to pass dams when those routes were available. For example, Rayamajhi et al. (2013) estimated fish passage efficiency (passage routes other than turbines) at 91 and 84 percent in 2013 at The Dalles and Bonneville Dams, respectively. At both projects passage survival through spillways and surface flow outlets was estimated in the low 90s while turbine passage survival was estimated in the low70s. Normandeau et al. (2014) conducted an adult steelhead balloon tagging study at McNary Dam and found that 98 percent of the steelhead passing the temporary spillway weirs were injury-free. The fish released through the turbine unit had more life-threatening injuries, presumably caused by blade strike and shear forces. Colotelo et al. (2013) also found that the survival of adult steelhead kelts through spillways and surface weirs was high (greater than 95 percent) and survival through turbine units was lower (less than 80 percent), indicating that kelts and potentially steelhead overshoots survive at a higher rate when spill protection is provided when they migrate back downstream.

Table 3-70 displays the CSS model results for Snake River steelhead. NWFSC LCM modeling for Snake River steelhead was not available. Overall Lower Granite to Bonneville SARs for wild Snake River steelhead have ranged from 0.25 to 3.95 (arithmetic mean of 2.03 percent) between 2006-2015 (Table B.36, 2018 Final CSS Report).

**Table 3-70. Model Metrics Related to Adult Survival and Abundance of Snake River Steelhead under the No Action Alternative**

| Metric (Model) | NAA |
| --- | --- |
| SARs LGR-LGR (CSS) | 1.8 |

Snake River Coho Salmon

See Snake River spring/summer-run Chinook as a surrogate for juvenile Snake River coho salmon and Snake River fall-run Chinook as a surrogate for adult Snake River coho salmon.

*Summary of Key Effects*

The primary effects for Snake River coho salmon involve both downstream and upstream passage through eight Federal dams and their reservoirs. Changes in dam reservoir environments in the Snake River may affect the susceptibility of Snake River juvenile coho salmon to fish-eating predators (e.g., channel catfish, walleye, pikeminnow, and smallmouth bass), which become more active at warmer water temperatures.

Snake River Sockeye Salmon

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake River sockeye salmon.

*Summary of Key Effects*

The primary issues for Snake River sockeye salmon are the conditions encountered during upstream and downstream migrations. Longer downstream juvenile migration passage and timing at projects put sockeye salmon at risk for effects associated with higher water temperatures, predation, or physical effects over a longer period than historically occurred. For adult sockeye salmon, the primary issue is high water temperatures.

*Juvenile Migration/Survival*

Data for Snake River spring/summer run Chinook salmon were used as a surrogate for Snake River sockeye salmon to analyze survival and travel time. Snake River sockeye salmon typically display faster travel times and migrate at a deeper depth than Chinook salmon, so they likely experience shorter travel times than those estimated by the surrogate species, under the No Action Alternative. Studies conducted by the middle Columbia River PUDs have also found juvenile sockeye to migrate at faster rates than yearling Chinook salmon (Timko et al. 2011; Blue Leaf 2012). Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake River sockeye salmon in Section 3.5.3.2.

Spill affects juvenile migration routes through the projects under the *Spill Operations to Improve Juvenile Passage* measure of the No Action Alternative. Increased spill generally reduces travel time as fish find spill routes more readily than turbine routes. Additionally, more spill generally means fewer powerhouse encounters, which would increase survival by not going through turbines. Snake River sockeye salmon are assumed to have similar survival rates and powerhouse encounter rates as Snake River spring/summer run Chinook salmon under the No Action Alternative.

Under the No Action Alternative, approximately 65,000 (11 percent) Snake River sockeye salmon would be transported annually through the *Juvenile Fish Transportation in the Columbia and Snake Rivers* measure. Because there are relatively few studies that evaluate the benefits of transportation for Snake River sockeye salmon, there is less certainty regarding the effects of these operations.

TDG during the migration period can affect juvenile and adult Snake River sockeye salmon in the form of GBT. The parameter of concern is the number of days over 120 and 125 percent at Bonneville, McNary, and Lower Granite dams (Table 3-71). The No Action Alternative is expected to continue with similar rates to observed data.

**Table 3-71. Percent of Days with TDG above 120 Percent and 125 Percent 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 |
| Lower Granite Dam | 2.7 | 1.3 |

Juvenile Snake River sockeye salmon are susceptible to predation by other larger fish during their downstream migration. Literature estimates indicate that smallmouth bass, walleye, and northern pikeminnow remove large numbers of sockeye salmon smolts. However, under the No Action Alternative, it is difficult to measure and quantify these effects to Snake River sockeye salmon. Temperature during outmigration is sometimes used as a surrogate for estimating risk of loss to predators. However, the mean water temperature from April 15 to May 31 at McNary Dam is only 12.03°C and is unlikely to increase the metabolic rates of predators that eat more migrating smolts due to increased food needs associated with the higher water temperatures. Changes in predation rates under the No Action Alternative are not expected.

Avian predation on juvenile salmon is another important factor of surviving their outmigration. Roby et al. (2017) estimated avian predation of Snake River sockeye salmon at 5.9 percent. These rates are not expected to change under the No Action Alternative.

*Adult Migration/Survival*

See the Effects Common across Salmon and Steelhead section, under Section 3.5.2.2, for an overview of adult migration/survival effects on salmon and steelhead under the No Action Alternative.

Historic returns for Snake River sockeye salmon are so variable that the analysis used Snake River spring/summer-run Chinook salmon as a surrogate for Snake River sockeye salmon. For analysis of life cycle models and a description of potential latent effects of the CRS, refer to the Snake River spring/summer-run Chinook salmon section of the No Action Alternative.

Recent Snake River sockeye adult survival rates (2013 to 2017) from Bonneville Dam to McNary Dam have averaged about 60 percent, and adult survival from Bonneville Dam to Lower Granite Dam has averaged about 50 percent (NMFS 2019). These survival estimates account for total losses from all sources, including from effects from the dams and reservoirs, flow, temperature, disease, or other natural causes. Estimated survival rates for PIT-tagged sockeye salmon from Lower Granite dam to Redfish Lake, the Sawtooth Hatchery weir, or other locations vary from just over 0 percent to greater than 70 percent depending on water conditions and migration timing of a given year (Johnson et al. 2017). In addition, earlier fish survive at higher rates and fish that pass Lower Granite Dam after the first week in July generally do not survive to reach the Sawtooth Valley (Crozier et al. 2014; NMFS 2019). Adult migration success is not expected to change over time due to these factors under the No Action Alternative.

To reach Redfish Lake and their home spawning areas, this population of fish swims upstream more than 900 miles with an elevation gain of over 6,500 feet. Along this route, Snake River sockeye salmon encounter eight dams. Adult Snake River sockeye salmon encounter upstream migration difficulties in the form of reduced homing ability if they were transported downstream as juveniles, as well as high water temperatures and TDG levels. The water temperature differential between river water and fish ladder water can often make sockeye salmon hesitate to enter and ascend the ladders.

Adult sockeye salmon that were transported downstream as juveniles exhibit a higher rate of fallback (i.e., salmon that pass two or more times the same project on the same day or on a later day), reduced homing ability, and longer migration time on their upstream migration compared to the fish that migrated in-river as juveniles. This causes a longer adult upstream migration time, which takes more energy and can reduce fitness for spawning once the destination is reached. Approximately 39 percent of juveniles are transported, and transported sockeye salmon are 2.9 times more likely to fall back and experience delay as adults (Crozier et al. 2015). This rate is expected to continue under the No Action Alternative.

Higher water temperatures correspond to lower adult survival. Adult survival rate has been less than 50 percent when water temperature is greater than 18°C measured at Bonneville Dam. High temperatures can also cause delays in upstream migration. Under the No Action Alternative, temperatures would exceed 18°C at Ice Harbor approximately 78 percent of all days during the sockeye salmon migration (June 21 to July 31).

During upstream migration, a temperature differential of more than 2°C in the fish ladders compared to river water can delay adult migration. During adult migration (June 21 to July 31), approximately 50.1 percent of all days have a temperature differential greater than 2°C. This would continue under the No Action Alternative.

Other water quality parameters include sediment levels measured in total suspended solids and DO concentrations. Both parameters are measured in mg/L. The average sediment concentrations in current conditions are approximately 2 mg/L and no change is anticipated in the No Action Alternative. The typical DO concentrations in the Snake River are between 9.5 and 11 mg/L, which poses no adverse effect for fish species. Under the No Action Alternative, no adverse effects are expected from the oxygen concentrations.

<u>Snake River Fall-Run Chinook Salmon</u>

*Summary of Key Effects*

Unlike most other ESUs discussed, Snake River Fall Chinook salmon spawn within the mainstem of the Snake River; therefore, the area that would be directly impacted by the operation of CRS projects could impact larval development and juvenile rearing.

*Larval Development/Juvenile Rearing*

For eggs to develop properly in their gravel nests, called redds, the adult spawners must have access to acceptable sizes of spawning gravel; the appropriate gravel size allows for water to bring in oxygen and clear wastes from the embryos until they grow to fry size and emerge from the gravel. Suitable sediment sizes for spawning are between 1 and 6 inches (Geist and Dauble 1998). Within the lower Snake River, fall Chinook spawning habitats are limited to tailwater areas of each of the four lower Snake River dams and sections of the Clearwater and Snake River above Lower Granite Dam. Under the No Action Alternative, spawning sites are not expected to change.

Some juvenile Chinook salmon that originate in the Clearwater River use reservoirs as rearing habitat and overwinter in reservoirs before migrating downstream as yearlings. Under the No Action Alternative, all reservoirs that support this life history type would continue to provide juvenile rearing habitat.

*Juvenile Migration/Survival*

Temperature affects juvenile salmon survival via predation, increased energetic requirements, and susceptibility to disease (e.g., columnaris). During the juvenile outmigration period, concentrations of juvenile salmonids at dam structures make them more susceptible to predators that are larger fish (e.g., channel catfish, walleye, pikeminnow, and smallmouth bass), which become more active at warmer water temperatures. The threshold for higher risk is thought to be 20°C, but these predators become active at even cooler temperatures. To analyze potential effects to juvenile from predation, an increase or decrease in mainstem temperatures during migration is used as a surrogate for predation risk. Average temperature at Ice Harbor Dam between May and July is measured and the risk index is calculated as the percent of days over 20°C. The Snake River's mainstem water temperatures have a mean temperature of 16.5°C and 26.6 percent of days over 20°C. Current water temperatures have minor effects to juvenile Chinook salmon through the mechanisms listed above; however, it is unknown what total number of these fish are lost to predation. The No Action Alternative is expected to continue the existing conditions.

Bird predation on juvenile salmon is another factor that determines juvenile salmon surviving their outmigration. It is estimated that gulls, cormorants, terns, and pelicans consume 11.6 percent of Snake River fall-run Chinook salmon (Evans et al. 2018). Nesting habitat is used as a measure for predation risk from bird predators. These risks would remain the same under the No Action Alternative.

During juvenile outmigration, instances of higher turbidity can decrease predation rates because reduced clarity of water hides juveniles so their susceptibility to predation decreases. The No Action Alternative is expected to have no changes to timing and duration of higher turbidity.

Approximately 1.5 million Snake River Fall Chinook salmon would be transported under the No Action Alternative each year (39 percent). Recent studies indicate that there is an advantage to transporting Snake River Fall Chinook later in the season. Smith et al. (2017) suggested transporting these fish, beginning on July 1 each year, would maximize returns.

*Adult Migration/Survival*

Adults migrating upstream have been studied for effects of having been barged downstream as juveniles and were found to have increased straying rates relative to juveniles that completed in-river migration downstream to the estuary (Bond et al. 2017). The effect can be estimated from the proportion and timing of juveniles transported downstream from collector projects. Bond et al. (2017) found that adult fall-run Chinook salmon bound for the Snake River were more likely to stray into the upper Columbia River if they were barged as juveniles. Under the No Action Alternative, *Juvenile Fish Transportation in the Columbia and Snake Rivers* measure, fall-run Chinook transportation would continue at approximately 39 percent of the juvenile outmigrant population. While this action improves the total number of fish that return, it would continue the rate of straying to other tributaries and basins.

High water temperatures can cause migrating adult salmon to stop or delay their migration or can increase fallback after ascending a dam. When they exceed 20°C, water temperatures delay adult migration during summer/fall. To analyze potential effects, the frequency that water temperatures in the reach of Lower Granite to Bonneville Dam exceed 20°C August to September was used as measured at McNary and Ice Harbor Dams. At McNary Dam, 58.3 percent of all days are over 20°C, and at Ice Harbor, 54.3 percent of days are over 20°C. During August and September under the No Action Alternative, nearly 60 percent of all days at McNary and Ice Harbor Dams are expected to be over 20°C. Delays in adult migration are expected due to elevated temperatures during August. The effect becomes reduced downriver in this reach.

During the peak migration period through the dams (August and September), approximately 50.1 percent of all days have a temperature differential greater than 2°C.

In addition to finding appropriate gravel sizes, the depth of water is necessary for successful deposit of fertilized eggs into the gravel. Fall Chinook salmon vary in the depth of water they select; the range in the Snake River Basin was found to be from 3 to 26 feet deep (1.0 to 8.1 m;

Geist and Dauble 1995; Dauble et al. 1999). The No Action Alternative would not change current conditions in the CRS project area.

Other water quality parameters include sediment levels measured in total suspended solids and DO concentrations. Both parameters are measured in mg/L. The average sediment concentrations in current conditions are approximately 2 mg/L, and no change is anticipated in the No Action Alternative. The typical DO concentrations in the Snake River are between 9.5 and 11 mg/L, which poses no adverse effect for fish species. Under the No Action Alternative, no adverse effects are expected from the oxygen concentrations.

***Lower Columbia River Salmon and Steelhead***

Lower Columbia River Chinook Salmon

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower Columbia River Chinook salmon.

*Summary of Key Effects*

Lower Columbia River Chinook salmon are primarily affected by factors outside the scope of the operations and maintenance of the CRS, but to some extent Lower Columbia River Chinook salmon could be affected by passage conditions at Bonneville Dam, and to a lesser extent, The Dalles Dam. Only five of 32 populations in this ESU are affected by passage conditions at Bonneville Dam and, to a lesser extent, The Dalles Dam: upper Gorge Fall Run, White Salmon Fall Run, Hood River Fall Run, White Salmon Spring Run, and Hood River Spring Run Chinook salmon.

Spill and flows affect the migration survival and travel timing of juveniles. Adults are influenced from operation of the CRS under the No Action Alternative primarily by spill; as the percentage of spill increases, so does the likelihood of adult Lower Columbia River Chinook being pushed downstream (i.e., fallback) below Bonneville Dam. Water temperature and TDG are also considerations for adult and juvenile survival. These are influenced by the following measures under the No Action Alternative: *Spill Operations, Lower Columbia and Snake River Operations*, *Water Quality Plan for TDG and Water Temperature*, *Spill Operations to Improve Juvenile Passage,* and the *Fish Passage Plan*.

No Action Alternative results for metrics used to compare MOs for Lower Columbia River Chinook salmon include the following:

- Juvenile project survival, Bonneville reservoir and dam (using Snake River spring-run/summer-run Chinook salmon as a surrogate) estimated at 89.0 percent
- Bonneville Dam outflows, April to June
- Bonneville Dam outflows, August to September
- Spill proportion, Bonneville Dam

- Temperature, The Dalles Dam, days exceeding state standard = 71 days
- Temperature, Bonneville Dam, days exceeding state standard = 58 days
- TDG, The Dalles Dam, days exceeding state standard = 33 days
- TDG, Bonneville Dam, days exceeding state standard = 61 days

*Juvenile Migration/Survival*

The change in juvenile survival for the portion of the fish passing Bonneville Dam were assessed using Snake River spring-run/summer-run Chinook salmon as a surrogate. Interestingly, Bonneville Dam is the only CRS project where higher spill can result in lower juvenile survival and vice-versa (personal communication, Zabel). Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile migration and survival of lower Columbia River Chinook salmon.

Some lower Columbia River Chinook salmon juveniles migrate in the spring; their travel time can be affected by changes in spring (April through July) flows. Other Lower Columbia River Chinook salmon juveniles emigrate in late summer or early autumn and rely heavily on estuary habitats before moving on out to the ocean. These juveniles are also subject to effects from increased TDG to some extent. Under the No Action Alternative, TDG would exceed the state standard a total of 33 days in The Dalles Dam tailrace and 61 days in the Bonneville Dam tailrace.

*Adult Migration/Survival*

The area where Lower Columbia River Chinook salmon experience the effects of the CRS the most is near Bonneville Dam, and to lesser extent, The Dalles Dam. Based on PIT-tag detections of surrogate species Snake River spring-run/summer-run Chinook salmon, at Bonneville Dam and later redetected at upstream dams, observed estimates of upstream Chinook salmon survival rates were 98.6 percent (NMFS 2019). Under the No Action Alternative, adult lower Columbia River Chinook salmon are expected to have similarly high success rates in upstream passage at Bonneville Dam.

Adult Lower Columbia River Chinook salmon are vulnerable to predation throughout the lower Columbia River. This vulnerability is primarily for the nine spring-run populations that migrate during May and June, when pinniped abundance is highest.

<u>Lower Columbia River Steelhead</u>

Four of the 23 populations in the Lower Columbia River steelhead DPS pass Bonneville Dam: Wind summer-run steelhead, Hood summer-run steelhead, Hood winter-run steelhead, and upper Gorge winter-run steelhead.

Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

*Summary of Key Effects*

Observed data estimated a 96.9 percent passage survival for juvenile Lower Columbia River steelhead at Bonneville Dam and passage at Bonneville Dam would be similar under the No Action Alternative's *Lower Columbia and Snake River Operations*, *Spill Operations to Improve Juvenile Fish Passage*, and *Fish Passage Plan* measures.

No Action Alternative results for metrics used to compare MOs for lower Columbia River steelhead include the following:

- Juvenile project survival, Bonneville Reservoir and Dam (see Snake River steelhead as a surrogate) = 87.3 percent
- Bonneville Dam outflows, March to June (juvenile outmigration)
- Bonneville Dam outflows, adult migration time period year-round
- Spill proportion, Bonneville Dam
- Temperature, The Dalles Dam, days exceeding state standard = 71 days
- Temperature, Bonneville Dam, days exceeding state standard = 58 days
- TDG, The Dalles Dam, days exceeding state standard = 33 days
- TDG, Bonneville Dam, days exceeding state standard = 61 days

*Juvenile Migration/Survival*

Ploskey et al. (2012) found actual survival of juvenile steelhead through Bonneville Dam to be 96.9 percent. These results were based on a study that looked at survival through the spillway, Powerhouse 2 and Powerhouse 1. Snake River steelhead was used as a surrogate to provide an estimate of juvenile passage survival through Bonneville Dam for those populations located upstream of Bonneville Dam. Under the No Action Alternative, juvenile survival through Bonneville Reservoir and Dam would be 87.3 percent. Based on observed data (Ploskey et al. 2012) and modeled surrogate species information, juvenile survival through Bonneville Dam would be 87 to 97 percent. Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead for additional juvenile migration and survival information.

For all Lower Columbia steelhead, including those populations that do not pass Bonneville Dam, reduced flows April through June from CRS operation would increase travel times and reduce access to high-quality estuarine habitats (NMFS 2019). In addition, exposure to increased temperatures and elevated TDG during outmigration would further influence juvenile survival.

Researchers have not estimated predation rates for Lower Columbia River steelhead because these fish are not PIT-tagged.

*Adult Migration/Survival*

The area where Lower Columbia River steelhead experience the effects of the existence and operation of the CRS is predominantly near Bonneville Dam, and to lesser extent, The Dalles Dam. The most recent estimates of upstream survival (Rayamajhi et al. 2012) indicate Lower Columbia River steelhead survival of adults passing upstream of Bonneville Dam is 98.5 percent.

Summer-run steelhead migrate upstream from May to October, and winter-run steelhead migrate December to May, so changes in flows, spill, temperature, or TDG could affect adult migration and survival. Additionally, kelts moving downstream post-spawning could also be affected during and soon after these times. Migration of kelts occurs from March through July (Keefer et. al, 2016). Kelt migration can be affected by the extreme energetic demands of spawning and iteroparity, harvest, and the Columbia River System (Coletelo et al. 2014). Refer to Middle Columbia River Steelhead in Section 3.5.3.2 for additional information on kelts and system passage.

Adult Lower Columbia River steelhead are vulnerable to pinniped predation throughout the lower Columbia River. This vulnerability is primarily for spring-run adult populations that migrate during May and June, when pinniped abundance is highest.

<u>Lower Columbia River Coho Salmon</u>

The ESA-listed Lower Columbia River coho salmon ESU includes three geographical groupings (or strata): Coast, Cascade, and Gorge. Only Gorge coho salmon travel upstream far enough to pass Bonneville Dam.

See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult Lower Columbia River coho salmon.

*Summary of Key Effects*

Survival rates of Lower Columbia River coho salmon transiting through the Bonneville pool and Bonneville Dam are expected to remain similar or increase somewhat under the No Action Alternative, due to the installation of the Bonneville Corner Collector and the *Lower Columbia and Snake River Operations, Spill Operations to Improve Juvenile Fish Passage*, and *Fish Passage Plan* measures. Modeled data includes historical records of fish passage before the Bonneville Corner Collector as constructed.

*Juvenile Migration/Survival*

Passage through the Bonneville Reservoir and Dam would continue to affect the survival of Lower Columbia River juvenile coho salmon under the No Action Alternative. Juvenile coho salmon outmigration timing generally overlaps with that of Snake River spring-run/summer-run Chinook salmon, and the size of these juvenile species are closely aligned; therefore, the Snake River spring-run/summer-run Chinook salmon were used as a surrogate for the Lower Columbia

River juvenile coho salmon. Juvenile Snake River spring-run/summer-run Chinook salmon are estimated to have a 95 to 96 percent survival rate at Bonneville Dam (Ploskey et al. 2012). Coho salmon smolts from tributaries in the Bonneville Reservoir are likely to have similar survival rates passing downstream through Bonneville Dam (NMFS 2019).

Refer to the Snake River Spring/Summer Chinook Salmon section (Section 3.5.2.2), No Action Alternative, for additional information on juvenile survival rate estimates under the No Action Alternative.

*Adult Migration/Survival*

Lower Columbia River adult coho salmon are assumed to have passage success rates similar to that of all coho salmon (including reintroduced upper river species) passing Bonneville Dam. Because there are no adult coho salmon-specific passage survival models available, it was necessary to rely on historic survival rates for a surrogate species to estimate and compare adult coho salmon passage rates under the No Action Alternative.

The timing of adult coho salmon upstream migration generally overlaps with that of Snake River fall-run Chinook salmon; although the fall-run Chinook salmon migration tends to start earlier in some years. For these reasons, Snake River fall-run Chinook salmon were used as a surrogate for Lower Columbia River coho salmon.

Based on Snake River fall-run Chinook adult PIT-tag detections at Bonneville Dam between 2013 and 2017, the average survival rate for Lower Columbia River adult coho salmon passing upstream of the dam is 97.6 percent (94.5 to 100 percent; 2019 CRS BiOp). This applies only to populations that migrate to natal streams within the Bonneville pool. Under the No Action Alternative, Lower Columbia River adult coho salmon survival rates are expected to continue in this range.

<u>Columbia River Chum Salmon</u>

One population in this ESU would be affected by operations at Bonneville Dam: Upper Gorge chum salmon.

Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia River chum salmon.

*Summary of Key Effects*

Chum salmon rarely pass Bonneville Dam. For the period between 2008 and 2017, on average, 96 adults passed this dam each year. Chum spawning and incubation habitat is maintained through operations at Grand Coulee, which results in sufficient water passing through Bonneville Dam in 90 percent of years. Chum operations would continue at current levels under the No Action Alternative's *Chum Spawning Flow* measure.

*Larval Development/Juvenile Rearing*

Maintaining water saturation of 105 percent TDG or less from November 1 to April 30 appears to provide a sufficient level of protection to chum salmon eggs and sac fry incubating in the gravel downstream of Bonneville Dam. Under measures in the No Action Alternative, including *Spill Operations*, *Water Quality Plan for TDG and Water Temperature,* and *Spill Operations to Improve Juvenile Fish Passage*, chum sac fry would be exposed to TDG above 105 percent in 5 out of 80 years. Those exceedances all would occur in the mid- to late April timeframe when most of the chum have emerged from the gravel.

*Juvenile Migration/Survival*

There are no studies of downstream passage survival for juvenile Columbia River chum salmon. The survival of downstream migrants is likely to have improved in recent years and would be expected to continue under the No Action Alternative due to the construction of the Bonneville Corner Collector.

There is no direct estimate of Bonneville Dam and Reservoir passage specific to juvenile chum salmon, so juvenile Snake River spring-run/summer-run Chinook salmon were used as a surrogate to estimate effects to chum salmon. Juvenile Snake River spring-run/summer-run Chinook salmon are estimated to have a 95 to 96 percent survival rate at Bonneville Dam (Ploskey et al. 2012). 2012 Chum salmon smolts from tributaries in the Bonneville Reservoir are likely to have similar survival rates passing downstream through Bonneville Dam (NMFS 2019). Refer to Snake River spring/summer-run Chinook salmon analysis for additional surrogate information for Columbia River chum salmon. Grand Coulee is operated to balance the needs of multiple salmon species. The operations provide chum flows downstream of Bonneville Dam, along with Vernita Bar operations for fall-run Chinook salmon, and spring flow augmentation from the start of chum spawning in November through the end of chum emergence (approximately the end of April). The chum operation is intended to maintain sufficient water depth to protect chum spawning and incubation habitat at the Ives Island complex below Bonneville Dam. The Bonneville Dam tailwater elevation (measured at the Tanner Creek gage) affects chum access to the Ives/Pierce Islands spawning area. Tailwater elevations below 11.3 feet create connectivity issues to spawning channels and poorer conditions in the lower spawning elevation habitat. As tailwater elevations increase above 13.5 feet, some habitat in the lower elevations becomes unsuitable for chum due to higher water velocities. In addition, eggs spawned at higher elevations would be at higher risk of being dewatered later in the year if there is an insufficient water supply. Under the No Action Alternative, Bonneville Dam flows would be managed to prevent chum spawning at those higher elevations that are at greater risk of dewatering. How operations affect the ability of Grand Coulee to provide winter flows to protect chum redds and provide sufficient access to habitat was calculated using hydrology modeling. Under the No Action Alternative, chum flows would be met in 90 percent of years.

*Adult Migration/Survival*

Adult chum salmon counts at the ladders at Bonneville Dam have ranged from 17 in 2000 to 411 in 2003, averaging 107 adults passing Bonneville Dam per year. The most recent 10-year average (2008 to 2017) is 96 adults (McCann 2018), which is similar to the 107 adults mentioned above as the average number of adults moving upstream of Bonneville Dam between 2013 and 2017 based on dam counts. NMFS (2008a) estimated that the adult passage mortality rate for chum salmon at Bonneville Dam was similar to that of Snake River spring-run/summer-run Chinook salmon, which are present during the same time period (about 3.1 percent). Passage survival estimates incorporate passage under general operations and typical maintenance (e.g., screen blockages/cleaning) conditions, and previous survival estimates are anticipated to continue under the No Action Alternative.

Adult chum salmon are near the Bonneville Dam tailrace November to December each year, and therefore are not likely to be exposed to elevated levels of TDG. Eggs are present in the mainstem spawning area near the tailrace (the Ives/Pierce Island area) during winter, and fry are present in the bypass system at Bonneville Dam and the mainstem spawning area through May. The risk of GBT to these life stages is minimized by maintaining a Bonneville tailwater elevation of between 11.5 and 13 feet through spawning if reservoir elevations (indicative of available storage) and climate forecasts indicate this operation would be feasible (NMFS 2019). GBT risk is anticipated to remain at current levels under the No Action Alternative.

Pinniped predation on chum salmon is expected to increase based upon increasing numbers of pinnipeds. However, the magnitude of pinniped predation on chum salmon is likely lower than on spring-run Chinook salmon, due to fewer pinnipeds being present when chum salmon migrate.

**Other Anadromous Fish**

***Pacific Eulachon***

<u>Summary of Key Effects</u>

The time between the peak spawning runs, egg development, and larval emergence timed with the spring freshet to adequately disperse larvae to adequate food sources would continue to be highly variable, with an average of 168 days between spawning temperature triggers and peak flows (158 days in high-flow years, and 156 days in low-flow years). Freshwater flow rates can affect larval survival if reduced flow rates result in a mismatch of larvae and their planktonic food supply. Relatively low freshwater inputs into the nearshore environment would continue to moderately limit plankton food supply for larval eulachon in the April to July period. A hydrology analysis showed none of the MOs would appreciably affect the estuary/plume environment.

Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation rates on eulachon, whereas at lower flows, birds tend to switch to marine prey. Operation of the CRS system under the No Action Alternative would continue to result in lower peak turbidity levels in spring, but the relationship between turbidity and eulachon is not clear. Eulachon would continue to migrate into the Columbia River from November to March, with specific dates of migration and spawning based on a variety of environmental factors, including temperature, high tides, and ocean conditions (NMFS 2017). Modeled data for the No Action Alternative (based on the period of record for Bonneville tailwater temperatures) indicate that temperatures would typically be favorable for triggering upstream migration by mid to late November, with the spawning trigger (4°C) occurring in late December/early January of each run year. The location of spawning would continue to be dependent on the size of the run, as well as other environmental factors. Runs are expected occasionally as far up the Columbia River as Bonneville Dam. Bonneville Dam is near the upstream range of spawning, but it could continue to impede access further upstream in years of very large eulachon runs. Possible eulachon injury or mortality could continue if any eulachon pass through Bonneville Dam. Because Bonneville Dam is the near the upstream range of spawning, this would be a very minor impact. Tributary access to major spawning tributaries would remain unimpeded. Eulachon need pea-sized gravel and coarse sand for spawning. Substrate can be affected by flows, particularly during changes in peak flows. A portion of eulachon would continue mainstem spawning where appropriate substrate exists, and tributary spawning substrate would not be affected.

***Green Sturgeon***

<u>Summary of Key Effects</u>

Columbia River use by green sturgeon is limited to foraging habitat for adults. Key effects of the No Action Alternative are focused on how flows and temperatures influence the cues for entering the Columbia River as well as the availability and distribution of food sources.

Columbia River water temperatures (relative to ocean temperatures) cue the spring arrival and fall departure of green sturgeon. The date that water temperatures first reach 15°C in spring and the date that they drop below 15°C in the fall can be used as an indicator for arrival and departure in the estuary (Moser and Lindley 2007). Currently, green sturgeon arrive in June and leave in September or October. In some years, the arrival date can be as early as May and the departure date as late as December. Flows and water temperatures anticipated under the No Action Alternative are anticipated to result in green sturgeon migrating within a similar date range and are expected to continue supporting adequate rearing conditions.

Changes in Columbia River outflow can change the location of the saltwater/freshwater interface that is important for green sturgeon feeding. Under the No Action Alternative, the lower Columbia River would continue to provide good foraging habitat for green sturgeon.

### *Pacific Lamprey*

#### Ongoing Existing Mitigation Programs

There are numerous actions to benefit Pacific lamprey, including projects like the Pacific Lamprey Conservation Initiative and the Tribal Pacific Lamprey Restoration Plan. These plans improve understanding of Pacific Lamprey status and limiting factors, implement high-priority habitat restoration actions, increase populations through reintroduction and translocation efforts, and conduct artificial propagation research with plans to release hatchery juveniles in select areas pending an environmental assessment.

#### Summary of Key Effects

Unlike salmon and steelhead, larval lamprey spend several years rearing in the freshwater environment of the Columbia and Snake Rivers and tributaries. Factors important for lamprey relative to Columbia River System Operations include how they affect dam passage, flow and reservoir levels, water quality, predation, and habitat conditions. Key effects of the No Action Alternative on lamprey include continued effects to upstream migration of adults and downstream migration of juveniles in the form of passage delays, direct individual mortalities, and physical stress. The No Action Alternative also would continue effects on larval rearing via reservoir drawdowns and project maintenance dredging. Not enough years of dam passage efficiency data are available to determine whether recent passage improvements have had effects at the population scale and if the improvements would continue under the No Action Alternative.

#### Larval Development/Juvenile Rearing

System operations affect juvenile rearing in shallow waters when water elevation fluctuations dewater larvae that reside in soft substrates in the shoreline. Flow reduction rates that drop the amount of shoreline covered by water (shoreline inundation) at less than 4 inches per hour occur naturally; however, dam operations can cause a faster rate of water receding from the shore. Under the No Action Alternative, the effects of these more rapid fluctuations include changes to distribution of rearing habitat, direct mortality, and increased predation exposure[4].

[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.

<u>Juvenile Migration/Survival</u>

Water temperatures and physical structures affect juvenile lamprey during their outmigration. Juvenile outmigration typically occurs in late fall through the spring into early summer. High-flow freshet events typically trigger outmigration events. The evidence of this is the timing of when juvenile fish are found in the tributary screw traps; this timing occurs with freshet events in winter and aligns with annual summary hydrographs (Mesa et al. 2015). However, warmer temperatures affect juvenile outmigration as well, and they are compelled to move out of the higher elevations of the system faster in warmer water temperatures due to physiological stress. Temperature data modeled from three of the Lower Snake River Dams show the number of days the water temperature exceeds state standards, which is expected to continue in the No Action Alternative:

- Lower Granite Dam: 4.4 days
- Little Goose Dam: 37.0 days
- Lower Monumental Dam: 47.2 days

Juvenile lamprey pass the CRS projects through all downstream passage routes and can potentially be harmed in any of the project components. Relative distribution across passage routes is not well understood, so the magnitude of all the injury and mortality effects on juvenile lamprey is unknown. As juveniles migrate downstream from their rearing areas, they must pass as many as eight projects of the Lower Snake and Columbia Rivers.

The majority of juvenile lamprey swim low in the water column below the depth of screens and pass the CRS projects via turbines. Fyke net evaluations of run-of-river fish at John Day Dam, McNary Dam, Bonneville Dam, and other dams found the majority (more than 70 percent) of juvenile lamprey appeared to move downstream low in the water column, below the turbine intake bypass screens installed for salmonids (BioAnalysts Inc. 2000; Moursund et al. 2003; Monk et al. 2004). Results of these fyke net studies provide an estimate of relative use of turbines at approximately 70 percent versus juvenile bypass systems at about 30 percent.

Lampreys that survive these passage routes can become injured or disoriented, putting them at greater risk of predation. Direct observations of predation on juvenile lamprey in powerhouse tailraces suggest passage via this route is substantial.

Turbine cooling water strainers can entrain juvenile lampreys in the turbine scroll case located upstream of turbines, which results in mortality. The evidence of this harmful mechanism is through mortality counts from routine cooling water strainer inspections at CRS projects. The Corps has developed a design for exclusion of juvenile lamprey and other fish from cooling water strainer intakes. The design would be tested at Ice Harbor as turbines are replaced with Improved Fish Passage turbines (IFPs) (under the No Action Alternative's *Ice Harbor Projects Turbines 1 to 3 Replacement and Generator Rewind* measure).

Juveniles that do not directly enter the turbines can be harmed and killed by impingement (being pushed up against the screens); this occurs mostly in the extended length submersible bar screens at McNary, Little Goose, and Lower Granite Dams. The Corps has observed the direct mortality of juveniles and a high number of entangled fish (Moursund et al. 2001, 2003). Bar screen installations at McNary Dam have been delayed until mid-April each year since 2009 to reduce this effect based on timing of lamprey migration. At other locations, lamprey timing is concurrent so bar-screen installation for the protection of salmon is not delayed. Woven mesh screen reduces impingements, but this has not been installed due to cost. Note that some dams and powerhouses have no turbine intake bypass screens and that other dams have what appear to be relatively benign Submersed Traveling Screens that use woven mesh.

Juvenile lamprey that migrate higher in the water column can pass via spillways, which may cause injury or indirect effects. It is unknown what proportion of lamprey use this route, and therefore the magnitude of effects to the population is unknown. The evidence for use of this passage route is direct observation of tailrace predation by gulls; lamprey become disoriented at spillways and become more susceptible to predation (Zorich et al. 2010, 2011, 2012).

Routine maintenance dredging occurs every 3 to 5 years for navigation in the lower Snake River in a channel 14 feet deep and 250 feet wide associated with the four lower Snake River Dams. The Corps also periodically dredges at Bonneville forebay locations, including immediately upstream of Bradford Island Fish Ladder exit, and upstream of Washington-shore fish turbine units. Dredging is necessary to remove debris and ensure that fish passage facilities are operating as designed. Juvenile lampreys are susceptible to entrainment in dredging equipment, but the number of fish harmed or killed is unknown. Juvenile lamprey have highest densities in fine particle, high organic matter substrates rather than the coarse mineral sand found in the channel. Sampling during dredging at Bonneville reservoir found no lamprey present. Although juvenile lamprey may be present in areas targeted for dredging, densities are thought to be site specific and most likely seasonal. Direct effects of the dredging action on juvenile lamprey is not well understood. Under the No Action Alternative, navigation channel maintenance would continue to occur periodically. Maintenance dredging at Bonneville would be expected to continue as needed.

<u>Adult Migration/Survival</u>

Dams inhibit upstream migration of adult lamprey to spawning areas, causing direct mortality or physical stress. Each dam that must be ascended poses risk of mortality or contributes to stress that reduces fitness for spawning. There is a poor understanding of magnitude of the impact to populations.

Only a portion of lampreys that attempt to move upstream in the Columbia River can pass the dams and move into desired spawning areas. Dams create barriers despite having fish ladders, which were designed for adult salmon. Dams can cause direct mortality or physical stress among adult lamprey that use conventional fishways. The ladders (designed for salmon) have too high of velocities, difficult shapes of ladder steps, and right-angled corners that cause difficulty for ascending lamprey. Lamprey adult upstream passage has been low at Columbia

River dams (Bonneville, John Day, and The Dalles Dams) with 65 percent or lower passage efficiency (Moser et al. 2002a, 2002b; Keefer et al. 2012). McNary Dam adult passage efficiencies have ranged from 65 to 75 percent (Keefer et al. 2013). Upstream passage efficiency at Snake River dams has been higher than at Lower Columbia River dams (Stevens et al. 2016); recent fish passage improvements at Snake River dams have increased adult passage survival from 70 to 75 percent (Stevens et al. 2016).

Mainstem dams can cause direct mortality or physical stress among adult lamprey that use lamprey passage structures or are otherwise diverted into collection structures or traps. Corps biologists and Corps-funded researchers periodically find dead lamprey in lamprey passage structures or in holding tanks. Other than equipment failures, mortality causes are often unknown. High temperatures or other water quality issues may cause physical stress or mortality of individuals, particularly as lamprey are kept in holding tanks during extended periods of high temperatures. Other unknown factors are causing lamprey to turn around and descend the ladders when they are expected to be migrating upstream.

Dam passage efficiency is the number of tagged lampreys that passed a dam divided by the number of lampreys that approached a fishway. Median dam passage efficiencies across all study years (1997 to 2010) ranged from 44 percent at Bonneville Dam, up to 68 percent at The Dalles Dam (Keefer et al. 2012). A study in 2014 found dam passage efficiency was at 49 to 52 percent at Bonneville Dam, 47 percent at The Dalles Dam, 83 percent at John Day Dam, and 100 percent at McNary Dam (Clabough et al. 2015). The Lower Snake River Dams have similar dam passage efficiencies at 41 to 68 percent (Stevens et al. 2016).

What these low success rates for ladder ascension mean is that attrition through the system leads to fewer and fewer lampreys that are able to make it further upstream into the system and reduces access to desired spawning locations. Reduced distribution and abundance reduces the effect of pheromone attraction cues, which would occur when adults detect the pheromone outputs of rearing juveniles. After many years of this reduced recruitment of lamprey to their desired spawning reaches in the watershed, the system has seen degraded ecosystem and food web effects because lampreys transfer nutrients upstream, so fewer lampreys mean fewer nutrients.

Under the No Action Alternative, there would be a neutral to decreasing trend in mortality and an increase in passage efficiency over time as the Corps continues to investigate and address known lamprey passage impediments. Adult lamprey passage metrics are expected to remain consistent in the near future and improve incrementally as conventional fishway structures and operations are modified and lamprey passage structures are installed.

The relationships of other parameters, such as outflows, spill rates, and water temperatures, with lamprey migration and survival are not well understood. Outflows and water temperatures are monitored at all of the CRS projects. Lampreys generally migrate faster later in the summer through most reaches, coinciding with increasing river temperatures and decreasing river discharge (Keefer et al. 2012). Temperatures greater than 72°F cause stress to adult lamprey and can reduce migration success, although this is a rare occurrence at Bonneville. High flows and lower water temperatures correlate to poorer passage success and slower migration speed, but little is known about the migration cues used by adult lamprey and how these and migration timing interact. Keefer et al. (2012) speculated that higher flows associated with higher tailwater elevations at Bonneville might compromise attraction to fishway entrances, collection channels, and transition pools of ladders. These factors can affect distribution of lamprey throughout the basin. Lamprey appear to have a relatively flexible migration strategy, and in some conditions, can overwinter up to 2 years before spawning, although temperature conditions in the project facilities are unlikely to support this strategy. Effects of different mainstem flow and temperature conditions on spawning success remain unclear. Total attrition due to all these factors affects the whole population. All these parameters and effects are expected to remain constant under the No Action Alternative.

Other stressors, such as predation and contaminants, are known to affect lampreys. Predation on adults by sea lions at Bonneville Dam is well documented (Corps Annual Reports) and by white sturgeon is likely to occur. This predation risk can be exacerbated by the delay in adult migrations at the dams and interactions of the predators and prey within the project structures. Birds and mammals may also take the opportunity to capture lamprey in structures. All life stages of Pacific lamprey can be affected by contaminants (CRITFC 2011). Contaminants such as methyl mercury are bioaccumulated in larval lamprey and can have ecosystem effects on predators that prey on them (Bettaso and Goodman 2008). These effects would continue under the No Action Alternative.

***American Shad***

<u>Summary of Key Effects</u>

Shad are generalists that tolerate a wide range of conditions and thrive in reservoir habitats; populations are increasing in trend and distribution. Changes in project operations are not likely to influence their populations, but their distribution and migrations could be affected by changes in flow, temperatures, or food supply. Both adults and juveniles would continue to thrive with the abundance of reservoir conditions in the Snake and Columbia Rivers that tend to favor them over other native fish. They consume up to 30 percent of the zooplankton present in the rivers and are expected to continue to eat at least that same amount under the No Action Alternative. Upstream migrating adults would continue to crowd fish ladders in the basin but also provide a recreational fishing opportunity.

<u>Juvenile Migration/Survival</u>

Juvenile shad thrive in aquatic vegetation found in off-channel habitats provided by reservoir shorelines (Petersen et al. 2003; Gadomski and Barfoot 1998), and they feed on zooplankton from June to September. Under the No Action Alternative, the reservoirs associated with the CRS would continue to provide vegetated shoreline habitat and adequate zooplankton at the levels that support a robust juvenile shad population. Juvenile shad would continue to experience high survival in these conditions.

Adult Migration/Survival

Adult shad return to the Columbia River system to spawn when temperatures reach about 16°C, which would occur between June and August under the No Action Alternative. Though they migrate upstream successfully in all conditions, Hinrichsen et al. (2013) found shad migrate further upstream under lower dam discharges. Under the No Action Alternative, shad would continue to thrive and potentially crowd fish ladders that could interfere with salmon and steelhead migrations.

**RESIDENT FISH**

Resident fish were analyzed as fish communities generally at the scale at which they are managed and as related to CRS Projects. These communities in Region A include Hungry Horse/Flathead/Clark Fork (Hungry Horse Dam); Lake Pend Oreille (Albeni Falls Dam) and Pend Oreille River; and the Kootenai River, including Lake Koocanusa (Libby Dam).

**Region A**

Ongoing Existing Mitigation Programs

There are numerous ongoing actions to benefit resident fish. CKST and MFWP's Hungry Horse Mitigation projects address habitat loss in the Flathead basin from construction and operation of Hungry Horse Dam, and the inundation of 72 miles (125.8 km) of the South Fork Flathead River and its tributaries. Project work assesses population level effects of dam operations on native fishes, implements habitat improvement, habitat conservation, and fish passage actions, and quantifies and reduces the effects of non-native aquatic species on native fishes.

Part of the mitigation work for Hungry Horse Dam involves fish production at two small hatcheries in northern Montana. Bonneville funds Creston National Hatchery's production of 200,000 juvenile westslope cutthroat trout and 200,000 juvenile rainbow trout for stocking in Montana waters. Stocking occurs according to the fisheries management strategy of MFWP and CSKT. Bonneville also funded the construction of Sekokini Springs Isolation Facility for spawning, rearing, isolation, and release of genetically unique westslope cutthroat trout stocks originating from wild parent stocks.

Mitigation actions for the fish impacts of Libby Dam are coordinated with adjacent tribal, state, and provincial governments. Programs like the Libby Dam Fisheries Mitigation and Implementation Plan (Montana Fish Wildlife and Parks et al. 1998) seek to enhance fish stocks affected by the Columbia River System in the Montana portion of the Kootenai Watershed consistent with white sturgeon, bull trout, westslope cutthroat trout and redband trout conservation needs and requirements. This program implements and evaluates habitat enhancement to alleviate limiting factors to native species including projects to protect or enhance spawning, rearing, and over-wintering habitats. Additionally, since 2010, Bonneville has funded the Kootenai Tribe of Idaho (KTOI) to manage and implement habitat restoration measures within the Kootenai River downstream of Libby Dam. These habitat restoration actions have increased active floodplain, increased river pool depths, reduced erosion, and provided increased complexity and velocities to aid in the survival and potential reproduction of Kootenai River white sturgeon and potential benefit for the native salmonid populations as well. Bonneville also funds IDFG for ongoing burbot monitoring actions, including evaluating population demographics, spawning activity and natural recruitment, and other actions. In addition to their habitat work, KTOI operates the Kootenai Tribal sturgeon hatchery and the Tribal Twin Rivers sturgeon and burbot hatchery facility, which was constructed in 2014. These facilities have preserved sturgeon genetic and demographic diversity and have pioneered culture techniques for burbot.

Bonneville's F&W Program also provides funding to the Kalispel Tribe to develop and implement a resident fish mitigation program for the impacts from Albeni Falls Dam. This work includes improving bull trout habitat within the basin. Additional priorities are to restore habitats for westslope cutthroat trout and maintain the suppression effort on non-native predator and competitive fish species within the Pend Oreille Basin. Finally, through the 2018 Northern Idaho Wildlife Agreement, Bonneville and the State of Idaho work to protect and enhance 1,378 acres to fully address operational impacts of Albeni Falls Dam on wildlife. Much of this work will focus on the Clark Fork Delta and restoration of riparian habitat and the reestablishment of wetland plant communities, which will also benefit resident fish species.

#### ***Kootenai River Basin***

<u>Summary of Key Effects</u>

Currently, water releases from Libby Dam can have detrimental effects to fish species in the Kootenai River downstream of Libby Dam related to altered flow and temperature. Under the No Action Alternative, spring flows would continue to increase at a rate less than normalized rates. The diminished spring flows would continue to reduce aquatic food sources associated with inundated river habitats between Libby Dam and Kootenay Lake in British Columbia. Burbot populations would be expected to continue to grow in abundance with continuation of the burbot restoration efforts.

Under the No Action Alternative, fluctuations in discharge from Libby Dam in the winter would continue to adversely affect benthic organisms. Cottonwood seedlings would continue to have variable survival depending on timing, stage, and duration of spring flows, along with the winter stage during the ensuing winter. In addition, the discharge regime from Libby Dam would continue to not provide for successful burbot recruitment, and spring water temperatures would be too cold to allow for proper larval development.

<u>Habitat Effects Common to This Fish Community</u>

Important operational relationships affecting species in this basin are related to river flows due to the construction and operation of Libby Dam. Prolonged periods of reduced early spring flow from the dam has changed the river ecosystem from mid-March through mid-May. During this period, it is critical for river flow and stage to rise and inundate riparian and side channel habitat to promote productivity. Under the No Action Alternative, the rate of increase in spring flows would be about one-third of a more normalized hydrograph needed to establish productivity.

Bull Trout

Important operational relationships affecting bull trout habitat in this basin include reservoir elevations in Lake Koocanusa and the impact of these elevations on reservoir productivity, how reservoir temperatures influence discharge temperatures, and how discharges from Libby Dam affect downstream habitat inundation. Higher reservoir elevations in the warm summer months results in a thicker water layer in which primary production and zooplankton production (i.e., euphotic zone) occurs in Lake Koocanusa. High reservoir elevations during winter (which have a large quantity of cold water) reduce the ability to provide warm/normative discharge temperature during spring and early summer in the Kootenai River. Bull trout forage in the reservoir and rely on this production in the river for food the following winter. Lake productivity under the No Action Alternative would continue to beneficially affect bull trout (both ESA-listed in the U.S. and non-listed individuals in Canada) growth and/or survival in Lake Koocanusa (Marotz et al. 1996; Marotz et al. 1999). However, lower flows and colder temperatures in spring and summer would likely suppress primary and secondary production in the river downstream of Libby Dam.

The minimum elevation of Lake Koocanusa each year influences insect larvae production the following year. The minimum elevation of the reservoir is typically in mid-April. The higher this minimum elevation is each year, the greater the insect larvae production and the more food available for juvenile bull trout (Marotz et al. 1996; Marotz et al. 1999; Chisholm et al. 1989). Under the No Action Alternative, the minimum reservoir elevation would be 2,366 feet during median years.

The maximum elevation of Lake Koocanusa is related to volume and surface area and to the proximity of the reservoir surface to terrestrial insect deposition, a food source for bull trout. The reservoir typically reaches maximum elevation in early August (Marotz et al. 1996; Sylvester et al. 2019). Under the No Action Alternative, the median maximum reservoir elevation would be 2453.1 feet, which is 5.9 feet below full pool.

Water temperature in Lake Koocanusa influences bull trout habitat suitability in the reservoir. Reservoir surface elevation and volume also influence the thermal structure of the pool. Reservoir temperature (Dunnigan, unpublished) is determined by several variables, the most indicative of which are volume of the reservoir through the winter (as measured by minimum pool elevation in April), inflow, and air temperature. Fish seek preferred temperatures, and the volume and temperature ranges influence the amount of preferred habitat. For bull trout, optimal growth occurs at 13.2°C, while the upper lethal temperature for bull trout is 20.9°C (Selong et al. 2001). Under the No Action Alternative, the mean monthly reservoir temperature from January to August (analysis was not performed September to December) would range from 3.5°C in March to 11.3°C in August. Reservoir water temperatures would be suitable for bull trout under the No Action Alternative.

Water temperatures in the reservoir also influence temperatures in the Kootenai River downstream of Libby Dam. Libby Dam discharge water temperature is manageable seasonally when the reservoir stratifies. During this time, a selective withdrawal system is used to release water from the reservoir forebay that is closer in temperature to what would have been the normal water temperature before the dam was constructed (Corps unpublished). Under the No Action Alternative, the mean monthly temperature of the discharge water from Libby Dam from January to August was assumed to be the same as for the water temperature in Lake Koocanusa. Bull trout temperature objectives would be met under the No Action Alternative from June to December via operation of the selective withdrawal system, though optimal growth temperature is met only intermittently via use of the selective withdrawal system. However, the No Action Alternative does not provide the ability to meet temperature objectives during late winter through late spring because the reservoir is no longer stratified. In addition, the amount of heat that the water in the reservoir can hold at the over-winter elevation would dictate the Libby Dam discharge temperature.

Discharges from Libby Dam would affect habitats for bull trout in the Kootenai River below the dam. Maximum high flows greater than or equal to 20 kcfs are needed seasonally during the spring freshet period of May 15 through June 15 to flush and sort fine sediments and gravels. These flows promote macroinvertebrate production and inundate productive varial zone habitats (i.e., the edges of the reservoir that alternate between being wet and dry depending on the reservoir water levels; see the Macroinvertebrates section below). Under the No Action Alternative through the *Kootenai River Operations for Bull Trout* measure, Libby Dam would provide a discharge of 20 kcfs or greater for 11 to 16 days (25th to 75th percentile) during the spring freshet. The mean flow rate would be 18.2 to 20.8 kcfs, with a peak discharge of 23.1 to 26.9 kcfs. This would support seasonal flow objectives for flushing and sorting sediments and gravels. However, these higher flows are insufficient to reshape tributary deltas that have been formed by excessive tributary bedload and insufficient river discharge. These deltas can prevent bull trout access during the fall (low river flow) spawning season (Marotz et al. 1996; Hauer et al. 2016).

Food availability for bull trout, off-channel inundation, and connectivity would be optimized with discharges of 9 to 12 kcfs from Libby Dam during the minimum flow requirement period for bull trout of May 15 to September 30 (Hoffman et al. 2002; Marotz et al. 1996; USFWS 2006). The No Action Alternative would provide a median discharge of 10.7 to 15.1 kcfs during this period; therefore, this alternative would support varial zone and off-channel inundation and productivity objectives for bull trout.

<u>Kootenai River White Sturgeon</u>

Important operational relationships affecting Kootenai River white sturgeon in this basin are related to how discharge and temperature affect spawning behavior and location, as well as egg development. The more prolonged the peak discharge is between mid-May and mid-July, the greater the probability of adult Kootenai sturgeon moving to spawning areas and successfully spawning (USFWS 2006; IDFG unpublished data; Ross et al. 2018). The number of consecutive days of high/prolonged discharge of 30 kcfs or greater at Bonners Ferry was used to determine the ability of the alternative to provide desirable conditions for Kootenai sturgeon spawning. The No Action Alternative would provide an average of 19 consecutive days of peak discharge greater than or equal to 30 kcfs at Bonners Ferry between May 15 and July 15 under the *Sturgeon Operations at Libby Project* measure.

Water temperatures downstream of Libby Dam are influenced by the water temperatures in Lake Koocanusa and are important in inducing sturgeon spawning. Higher pool elevations through the winter associated with system flood risk management protocols can result in colder water that warms more slowly than optimal during spring and early summer, which in turn results in cooler and more variable discharge temperatures (personal communication, Hoffman 2019). Lower pool elevation in the winter can result in faster springtime warming of the forebay, and warmer, less variable discharge temperatures during spring and early summer. Warmer water (8.5°C to 12°C) is needed in late-May through late-June for sturgeon spawning (Paragamian and Wakkinen 2011). Egg deposition generally occurs at temperatures greater than 8°C with a peak at about 9.5°C (Paragamian and Wakkinen 2011). Under the No Action Alternative, the median mean reservoir water temperature for spring and early summer at Lake Koocanusa 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 July. The mean water temperature discharged from Libby Dam under the No Action Alternative meets temperature objectives in June but is still too cold in May. In addition, this alternative would not meet the pre-spawning temperature objectives for productivity because over-winter reservoir volumes influence reservoir temperature (see previous temperature discussion).

In a similar way, water temperatures further downstream at Bonners Ferry are also important in determining the potential for Kootenai sturgeon spawning. The same water temperatures are required for successful spawning and egg deposition. Under the No Action Alternative, the mean monthly temperatures at Bonners Ferry are approximately 2°C warmer than below Libby Dam (8.3°C in May, 11.1°C in June, and 13.5°C in July) and would be more conducive to successful sturgeon spawning at this site.

Water temperature affects incubation and larval development. Pre-dam temperatures in the Kootenai River were consistently cold November to March, and then rose sharply in April and May. Higher water temperatures reduce incubation time (Paragamian and Wakkinen 2011). Water temperatures of about 6°C in mid-March that increase to about 14°C by the end of June are needed for proper development of sturgeon (Hardy and Young, unpublished). Under the No Action Alternative, the mean monthly water temperature at Bonners Ferry would be below those temperatures, ranging from 3.8°C in March to 11.1°C in mid-June. This would not support development of post-hatch larval and juvenile sturgeon.

Bonners Ferry peak flows and the duration of high flows can provide connectivity to backwater and slough habitats that are important for Kootenai sturgeon larval and juvenile rearing. These flows provide warmer water over inundated, productive floodplains that provide better conditions for sturgeon development and growth. Any increase in access to side channel and floodplain habitats would be beneficial to sturgeon. The number of days that water levels were above 1,758 feet at Bonners Ferry was used to evaluate the extent of inundation under each alternative. The greater the number of days that water levels are above this elevation, the greater the extent of inundation. Under the No Action Alternative, the river would be above elevation 1,758 feet at Bonners Ferry for an average of 17 days during the sturgeon spawning period. The No Action Alternative would provide for some unknown level of larval and juvenile sturgeon rearing habitat.

<u>Other Fish</u>

Entrainment of young-of-year and adult kokanee through Libby Dam results in adverse effects to kokanee populations. Peak entrainment densities can occur from early spring into mid-summer, and during fall through early winter (Skaar et al. 1996), depending on kokanee density and distribution in the forebay. Higher discharges are correlated with higher entrainment. Fish entrainment rates increase with higher discharge rates.

Many effects to habitat conditions for rainbow/redband trout and westslope cutthroat trout under the No Action Alternative would be similar to those for bull trout. As with bull trout, important operational relationships affecting rainbow/redband trout and westslope cutthroat trout habitat in this basin are related to how reservoir elevations in Lake Koocanusa affect productivity and food organisms in the reservoir, how reservoir temperatures influence discharge temperature, and how discharge shape and volume influence habitat suitability in the river downstream of Libby Dam.

Higher reservoir elevations in the warm summer months would provide a larger euphotic zone where primary production and zooplankton production would occur in Lake Koocanusa. As with bull trout, the westslope cutthroat trout food base relies on this production for food the following winter. The expected increase in productivity from a larger body of warm water would likely have a beneficial effect on westslope cutthroat trout growth and/or survival (Marotz et al. 1996).

The effect of the minimum elevation of Lake Koocanusa under the No Action Alternative would be the same for rainbow/redband trout and westslope cutthroat trout as for bull trout. The higher the minimum elevation, the greater the insect larvae production and the more food available for juvenile westslope cutthroat trout (Marotz et al. 1996; Chisholm et al. 1989). The median minimum reservoir elevation under the No Action Alternative would be 2,366 feet.

The effect of the maximum elevation of Lake Koocanusa as related to volume, surface area, and proximity of the reservoir surface to terrestrial insect deposition would be the same for rainbow/redband trout and westslope cutthroat trout under the No Action Alternative as for bull trout. Under the No Action Alternative, this elevation would typically be 2453.1 in early August during median years.

Rainbow/redband trout and westslope cutthroat trout optimal growth occurs at 13.1°C and 13.6°C, respectively (Bear et al. 2007). Under the No Action Alternative, the mean monthly (water column mean) reservoir temperature from January to August (September to December were not analyzed) would range from 3.5°C in March to 11.3°C in August. This indicates the No

Action Alternative does provide the ability to meet temperature objectives for rainbow/redband trout and westslope cutthroat trout in the reservoir, as fish would be able to find the preferred temperatures they seek.

Libby Dam discharge water temperature is manageable seasonally (when the reservoir stratifies) using the selective withdrawal system to release water from the reservoir forebay that is closer to pre-dam river temperatures. The No Action Alternative would continue to provide the ability to meet temperature objectives for rainbow/redband trout and westslope cutthroat trout during early summer through early winter (June to December) via operation of the selective withdrawal system. However, the No Action Alternative does not provide the ability to meet temperature objectives during late winter through late spring, as the reservoir would be isothermic.

Discharges from Libby Dam would have the same effect on habitat for rainbow/redband and westslope cutthroat trout as for bull trout in the Kootenai River downstream from the dam. Maximum high discharges greater than or equal to 20 kcfs are needed annually during the spring freshet period to flush and sort fine sediments and gravels. Higher discharges (up to 25+ kcfs) of longer duration (up to 30+ days) are desired. Under the No Action Alternative, Libby Dam would provide discharges of 20 kcfs or greater for 11 to 16 days (25th to 75th percentile) during the spring freshet. This would support seasonal flow objectives for flushing and sorting sediments and gravels in the river below Libby Dam

Dewatering the varial zone of the Kootenai River during the productive season (June to September) reduces the density of the benthic invertebrate community. Benthic organisms die in less than 5 days in the dewatered zone, and it takes over a month and a half for them to recover after the substrate becomes re-wetted (Oasis Environmental 2011; Marotz and Althen 2005).

Under the No Action Alternative, winter operations at Libby Dam would continue to have winter ramping rates that are less protective than spring and summer rates, allowing for varial zone desiccation, re-inundation, and freezing. This may affect species bioenergetics and increase their metabolic activity and would be deleterious to benthic ecology, which would affect food organisms for rainbow/redband and westslope cutthroat trout. As mentioned under bull trout, no data are available to assess the within-day variability of the flows, and therefore this effect was not evaluated for any of the MOs.

Off-channel habitats are important for larval and juvenile burbot in the lower Kootenai River. These habitats provide warmer water, cover, and important forage. Similar to Kootenai River white sturgeon, the number of days that water levels were above 1,758 feet at Bonners Ferry was used to evaluate inundation under each alternative. The No Action Alternative would provide a median of 17 days above this elevation during the larval emergence and development stages of burbot, providing access to warmer and more productive rearing habitats for these days. This alternative would provide some floodplain connectivity for burbot; however, larval and juvenile burbot would benefit from an even longer duration of inundation.

Pre-dam flows and temperatures in the Kootenai River from November to March were low, stable, and cold. Burbot required these conditions for successful spawning and migration. Stable flows around of about 4 kcfs result in spawning congregations (based on empirical catch rates; IDFG cite), while daily load shaping and weekly load following result in high and variable flows and interrupted spawning migrations of adult burbot (Paragamian et al. 2005; Ross et al. 2018; Ashton et al. in press).

The modeled mean, maximum, and minimum flow at Bonners Ferry between January 1 and April 30 was used to represent the flow variability under each alternative. Under the No Action Alternative, the mean flow would be 13.4 kcfs, with an average maximum and an average minimum flow of 29.4 kcfs and 5.5 kcfs, respectively. Under the No Action Alternative, flows would not provide the appropriate discharge regime for successful burbot recruitment.

Water temperature is important for burbot egg incubation and larval development. Pre-dam temperatures in the Kootenai River were consistently cold November through March, and then rose sharply in April and May. Because discharge temperatures are too cold, and access to sufficient floodplain areas is limited, larval development is slowed and mortality increased.

Burbot need water temperatures of about 2°C in mid-February for spawning, egg incubation, and survival. Following spawning and early incubation, these fish need water temperatures to increase at a rate of over 2°C each month until they reach about 14°C by the end of June for normal development. Under the No Action Alternative, the mean monthly water temperature at Bonners Ferry would be below those temperatures, ranging from 3.88°F in March 11.1°C in mid-June. These temperatures would not provide appropriate mean monthly temperatures at Bonners Ferry for development of burbot. Early winter temperature would often be too warm for spawning and egg development and too cold for proper body development, growth, and survival.

A potential adverse effect on burbot is the entrainment of eggs and larval burbot through Libby Dam during March and early April. Although not explicitly quantified, the lower the discharge, the fewer the number of eggs and larvae would be entrained (Skaar et al. 1996). Modeling results show the median Libby Dam discharge between March 1 and April 15 would be 4 to 11 kcfs under the No Action Alternative; the effects of this discharge are not quantifiable.

#### ***Hungry Horse/Flathead/Clark Fork Fish Communities***

<u>Summary of Key Effects</u>

Hungry Horse Reservoir is a naturally cold, nutrient-poor reservoir; as such it has poor algae and zooplankton production but typically good water quality. Successful reproduction drives fish populations, but food availability is very important. Many of the important relationships between operations and fish in the reservoir focus on primary and secondary food production and the entrainment of both fish and zooplankton out of Hungry Horse Reservoir. In addition to these effects, reservoir elevations also influence the ability of migrating fish to access tributaries to spawn, and lower lake elevations increase the risk of predation and angling exploitation fishing on these fish in the varial zone. In the river below Hungry Horse, changes in temperatures and flows due to dam operations influence habitat suitability, and these effects continue downstream to the mainstem Flathead River and into Flathead Lake, then beyond into the lower Flathead River and Clark Fork River.

Habitat Effects Common to This Fish Community

Hungry Horse operations influence food web production in several ways:

- Lake elevations in the warm summer months influence the volume of warm, productive water for primary production and zooplankton production. This primary production in the summer provides food for the zooplankton that become an important food source for fish the following fall and winter (Fraley and Graham 1982, Fraley and Shepard 1989).
- The magnitude and rate of reservoir drawdown influences the production of benthic insects on the reservoir bottom from the water's edge down as far as light can penetrate. Insects need five to seven weeks of wetted substrate with light penetration in order to be productive. If areas are dewatered before this process is complete, there is no production. Higher reservoir levels also provide for inundation of the large flat shallow areas at the upper end of the reservoir to be productive with aquatic insects. These are an important food source in the spring (May et al. 1988).
- Reservoir elevations influence the availability of terrestrial insects for fish. This is an important summer food source. Lower lake elevations equate to less surface area for these insects to land on the water and be eaten by fish. Further, two of the four orders of insects that are this food source (flies, bees, and wasps) are able to fly so they readily transport to the water surface, but the other two (beetles and leafhoppers) do not fly, so as the water recedes away from the terrestrial vegetation, these food items become less available as they simply drop to the ground rather than dropping in the water (May et al. 1988).
- Outflows, elevations, and the location of water withdrawal affect the loss of zooplankton through entrainment out of the dam and into the South Fork Flathead River (Cavigli et al. 1998).

Lake elevations also influence the ability of fish to access tributaries for spawning, as most species migrate upstream into these inflowing streams to spawn. At elevations near the top of the normal pool, there is generally good access into the tributaries directly from the lake. As elevations drop, fish must traverse a length of tributary flowing through the varial zone, or where previous inundation has resulted in sedimentation and lack of vegetation. In these areas, fish are more susceptible to predation, angling pressure, and reduced access to tributaries.

Lake elevation in the warm summer months determines the volume of reservoir that would be available to produce plankton (euphotic zone). Note as the summer goes on, this productive zone gets thicker. This was estimated by determining the modeled reservoir elevation at the end of each month, converting it to reservoir volume, then subtracting the volume of the reservoir lower zone that would not produce plankton. See Appendix F for additional detail.

Drawdowns through the summer affect this production as well as the production of insects that live on the bottom of the reservoir. As reservoir elevations drop, insects in this zone can become dewatered. The insect eggs would have been deposited within the euphotic zone described above. If reservoir levels drop, that zone remains the same thickness and drops with the surface level, but there would be no insects deposited at the lower elevation that is now the euphotic zone, so steeper drops in the elevation relate to less benthic insect production. In addition, the large bays at the upper end of the reservoir become dewatered with dropping levels over the summer. This would continue to result in the loss of some benthic insect production but would continue to be enough to support a healthy native fish community. Additionally, there are three lobes of the reservoir with different shapes that would tend to become dewatered at different rates; they are known as Emery (the main lobe towards the dam), Murray, and Sullivan.

The reservoir elevation determines the surface area available for terrestrial insects to land on the water and be available for fish food, as well as influencing the proximity of the water's edge to terrestrial vegetation and therefore the ability of the two non-flying orders of important insects to be available to fish by passively landing in the water. To evaluate the No Action Alternative, the end-of-month elevation was converted to surface area using bathymetric data (USBR unpublished data). See Appendix F for end-of-month surface area calculations.

Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry Horse Reservoir. The zooplankton enhances food supply in the South Fork Flathead River and along the near bank of the Flathead River but decreases food supply for fish in Hungry Horse Reservoir. Outflows, and therefore entrainment rates, are lower in the winter when the zooplankton are most important for fish.

Outflow patterns can also affect how fish are entrained into the South Fork Flathead River and the habitat conditions, such as river elevation (stage), velocities, and temperatures in the river. These effects continue downstream to affect the main Flathead River in the same patterns, but are somewhat attenuated by the flows in the mainstem Flathead River. Temperatures in summer are regulated with a selective withdrawal structure that is operated to release water at a temperature that favors native fish.

In the Flathead River down to Flathead Lake, habitat suitability is a key issue due to unnaturally high flows in the summer and winter. Under the No Action Alternative, summer flows would continue to be higher than natural, resulting in velocities that can be difficult for bull trout and other native fish, but the river would continue to provide habitat to support them. Higher-than-normal winter flows would continue to limit establishment of riparian vegetation important to fish. Spring peaks, although lower than natural, would continue to occasionally provide flushing of sediments from gravel to enhance production of benthic food sources.

Temperatures in the Flathead River would continue to be influenced by the contribution of the South Fork Flathead River with normalized temperatures in summer, when the selective withdrawal system operates. In the winter, the selective withdrawal structure is not operated so no longer useful to release targeted temperatures, but, in the winter, the reservoir is warmer than mainstem Flathead and so releases during this period are warmer than what would be normal. TDG in the Flathead River would continue to fluctuate with spill at Hungry Horse Dam but generally would not exceed 117 percent, which is within a safe zone for fish, under the *Operations to Limit TDG Production at the Hungry Horse Project* measure.

The influence of project operations on Seli'š Ksanka Qlispe' Dam and outflows Flathead Lake elevations is minor but could influence fish in the lower Flathead River and the Clark Fork River. Winter base flows out of Seli'š Ksanka Qlispe' Dam would typically be stable at about 7,700 cfs in January under the No Action Alternative, and summer flows are also artificially high.

Bull Trout

Hungry Horse Reservoir and its associated upstream tributaries support one of the healthiest populations of bull trout in their range. The productivity conditions described above as the No Action Alternative would continue to support this food web and bull trout. Reservoir elevations influence the access to spawning tributaries and the degree of varial zone effects, such as predation risk and exposure to angling exploitation that fish experience. Bull trout spawn in the fall. Changes in reservoir operations implemented in 2009 have reduced water level fluctuation during the summer and fall, which overlaps with the primary period when bull trout are migrating to spawning and overwintering habitats in tributaries (Reclamation 2009). In most years, tributary access and predation exposure and angling pressure in the varial zone are typically not an issue. The No Action Alternative would continue to provide access to spawning tributaries and limit varial zone effects. This could become a problem in low water years.

Bull trout entrainment through the dam is known to occur but the extent of entrainment has not been studied and the overall effect to populations is not known. It would be expected to continue at similar levels that do not impact overall populations. Bull trout are known to be present at depths greater than 100 feet near the dam and would be susceptible to being swept through the dam (i.e., entrainment), especially as the lake stratifies in the summer.

Bull trout in the South Fork Flathead River below Hungry Horse Reservoir are typically limited to either individuals entrained out of Hungry Horse or transitional use by individuals from the mainstem Flathead River, typically in October to July. There is not a spawning population in this stretch from Hungry Horse dam to the confluence with the Flathead River, and it is not designated critical habitat (FR 63898). As in the reservoir, food web relationships are important. The No Action Alternative would continue to allow for this transitory use by bull trout and other native fish with adequate food. Established minimum flows would continue to protect habitat, and ramping rate restrictions limit fluctuations.

The mainstem Flathead River would continue to provide conditions suitable for bull trout, with somewhat normalized temperatures, higher summer flows limiting slow-velocity habitat in summer, and higher winter flows limiting production of riparian vegetation.

Seli'š Ksanka Qlispe' Dam (Flathead Lake) operations would continue to potentially influence bull trout by occasional erosion events, causing water quality effects and favoring non-native fish such as northern pike in the bays and sloughs at the top of Flathead Lake. Bull trout use of

Flathead Lake would continue, and there could be some entrainment of bull trout at Seli'š Ksanka Qlispe' Dam into the lower Flathead River, particularly in cooler months when the temperatures would not exclude them from the large lobe of the lake near the outlet, though the extent is not known. Finally, the operations would continue to provide the flow regime to Seli'š Ksanka Qlispe' to operations downstream that support small, highly fragmented bull trout populations limited by dams and reservoirs influence on temperatures, flows, and non-native species on downstream in the Clark Fork River.

<u>Other Fish</u>

Hungry Horse Reservoir, as described in Section 3.5.1.4, favors a native-fish-dominated fish community. Juvenile bull trout and adult whitefish, northern pikeminnow, sculpins, and westslope cutthroat trout feed on zooplankton, aquatic insects, and terrestrial insects, and adult bull trout prey on mountain whitefish, suckers, and minnows. The food web effects described above would also apply to these species of fish in Hungry Horse Reservoir.

Westslope cutthroat trout and other native fish spawn in the spring (April to June), so the effects on adults migrating into tributaries to spawn would differ from bull trout. Spring spawning fish migrate when reservoir levels are lower and tend to experience longer varial zones with increased predation exposure, but access to tributaries is not typically problematic in most years.

Entrainment from the reservoir would also continue at current, unquantified levels, though westslope cutthroat trout would not be expected to be as susceptible as bull trout because they are not found at the depths of outlets like bull trout. Operations rules (VarQ), ramping rate restrictions, and minimum flows would continue to support the observed increasing trends of native fish and limit invasion by lake trout and brook trout.

A selective withdrawal structure and VarQ rules would continue to regulate temperatures to support a more natural thermal regime that is beneficial to native fish and minimize invasion by non-native fish such as lake trout from Flathead Lake. Westslope cutthroat trout in the Flathead River would continue to move up into the South Fork Flathead River when the temperature control structures operate. In Flathead Lake, northern pike are nearly beyond the time when their eggs would still be viable by the time the lake levels rise far enough for them to access spawning areas in bays, and further delay in refill could reduce their spawning success. Some entrainment out of Flathead Lake likely occurs but is unquantified.

Below Seli'š Ksanka Qlispe' Dam in the lower Flathead River and Clark Fork River, the altered hydrograph would favor non-native species; the fish community is dominated by non-natives but some bull trout and westslope cutthroat trout are also present. High winter flows limit riparian cover, and higher summer flows increase habitat for non-native fish such as walleye and smallmouth bass.

***Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River***

Summary of Key Effects

The No Action Alternative would not change the way bull trout are currently utilizing Lake Pend Oreille or the Pend Oreille River downstream of Albeni Falls Dam. Bull trout would continue to use Lake Pend Oreille from November to June when water temperatures are cooler, then move into tributaries in the summer. Sub-adult bull trout and non-spawning adults may remain and rear in the lake year-round. An unknown number of bull trout would be entrained at Albeni Falls Dam. These fish would likely perish in the summer when water temperatures in the river downstream of the dam reach lethal levels, although a small number (between 1-12 per year) may be recovered by temporary efforts to collect fish from the tailrace. A permanent trap and haul fishway may be completed during the period of analysis for the EIS. Kokanee would continue to be able to spawn, but their populations would be influenced by competition with opossum shrimp for food (zooplankton) coupled with predation by lake trout and other predatory fish species. Westslope cutthroat trout would continue to use Lake Pend Oreille, and an unknown number would be entrained at Albeni Falls Dam. Like bull trout, they would likely experience high mortality rates in the summer when water temperatures in the river downstream of the dam reach lethal levels. Some may be recovered by trap and haul efforts. Key effects for warmwater game fish such as pike, walleye, and smallmouth bass include stable spring water levels for spawning and rearing, winter drawdowns that interrupt juvenile rearing, adequate forage for large predators, and potential entrainment.

Habitat Effects Common to This Fish Community

As discussed in Appendix D, *Water Quality*, 7-3, *Albeni Falls*, temperature data collected in the lake in 2004 to 2006 showed surface water temperatures typically exceed 19°C by the end of June and reach a maximum of 24°C at the end of July. At depths below 14 m, temperatures are within the preferred range of bull trout during summer (less than 15°C). Colder water of 5°C and below is found throughout the summer in some locations. These water temperature patterns would be expected to continue under the No Action Alternative. The river section of Lake Pend Oreille does not provide cool water refugia. This is because the shallow low-water channel near Sandpoint, Idaho, acts as a heat source for downstream flows and blocks the movement of much colder subsurface water from Lake Pend Oreille into the river section. Large woody debris is not currently allowed to enter Lake Pend Oreille as it poses a safety hazard to boating. A log boom currently diverts debris coming into the lake.

Outflows from Albeni Falls Dam would affect rates of entrainment of fish from Lake Pend Oreille. Mean flows under the No Action Alternative in May and June would be about 50,700 and 55,600 cfs, respectively. Under the No Action Alternative, median flows are 23,700 cfs in October to draft Lake Pend Oreille. In the winter, median discharge is 14,500 cfs to 16,600 cfs. River temperatures below Albeni Falls Dam are expected to be similar to those in the river part of Lake Pend Oreille above the dam. These temperatures reach 15°C in June and lethal temperatures for cold water fish in July (Corps 2018). Under the No Action Alternative, these high summer water temperatures are expected to continue.

Bull Trout

Access to tributaries is important for bull trout in Lake Pend Oreille, as that is where they spawn. Under the No Action Alternative, bull trout would continue to have access to tributaries to Lake Pend Oreille during the spring and summer. Bull trout move into the tributaries when lake levels are high during May and June. Because Albeni Falls Dam operations affect sedimentation and erosion from the lake shorelines, this could indirectly affect bull trout access to tributary mouths due to sedimentation. During the upstream migration of bull trout in May to September, the pool elevation is rising or at the full pool elevation of 2,062 feet under the *Lake Pend Oreille Elevations for Kokanee and Bull Trout* measure. Gold and Granite Creeks may be affected more as fish move into these tributaries later in the year. However, current operations rarely affect tributary access during spring and summer (Corps 2018). Operations under the No Action Alternative would continue to provide access to most tributaries for bull trout.

Historically, bull trout from Lake Pend Oreille would migrate up the Clark Fork and spawn. The construction of Cabinet Gorge Dam on the Clark Fork in 1953 blocked those runs, and the genetics for that population may have been lost. In 2001, a trap-and-haul operation was implemented to capture adult bull trout at Cabinet Gorge Dam and transport them to sites upstream. On average approximately 35 adult bull trout are transported at this site each year. The design for an updated permanent fish trap at Cabinet Gorge Dam was finalized in 2018 (Avista 2017). Under the No Action Alternative, bull trout from the lake would continue to have passage to their historic habitat above Cabinet Gorge Dam, either from the trap-and-haul program or the new permanent fish trap.

An unknown number of bull trout are entrained through Albeni Falls Dam each year and are lost to the system, as there currently is no trap-and-haul program at Albeni Falls Dam to return them to the lake. However, a permanent trap and haul fishway may be completed during the period of analysis for the EIS that would allow these fish to return upstream. Entrainment is most common from March to June when flows are high (Corps 2018). Most populations of bull trout within Lake Pend Oreille are large enough that there are not likely to be major effects from entrainment. Entrainment is likely to continue under the No Action Alternative, with trap and haul reducing the number of fish lost in the future.

Under the No Action Alternative, water temperatures in Lake Pend Oreille would continue to be suitable for bull trout year-round in at least part of the lake. Bull trout prefer cold water with temperatures below 15°C (Barrows et al. 2016). In November through June when bull trout are present in the lake, surface temperatures range from about 4°C to 15°C, while temperatures in deeper water greater than about 65.6 feet (20 m) rarely exceed 15°C. In June to October, surface water temperatures would likely be too warm for bull trout (greater than 18°C), but deeper parts of the lake below the thermocline 45 ft. (14 m) or greater, would still provide cold water habitat (less than 15°C) suitable for bull trout. Temperature profiles from Appendix D show that water temperatures between June and October are likely too hot for bull trout in the river section of Lake Pend Oreille. This is because a shallow low-water channel near Sandpoint, Idaho, acts as a heat source for downstream flows and blocks the movement of much colder subsurface water from Lake Pend Oreille into the river section. This is likely to continue under the No Action Alternative.

The continuing loss of large woody debris along the shoreline is not likely to adversely affect bull trout; historically this debris settled out in shallow water habitat that has warmer surface water and is not likely to be used by bull trout.

Lake Pend Oreille would continue to provide adequate forage for bull trout under the No Action Alternative. Bull trout need robust kokanee populations for adequate forage as kokanee are the principal prey for adult bull trout (Hansen et al. 2019). Under current conditions, kokanee would continue to provide a good forage base for adult bull trout. Kokanee have increased from about 40 adult fish per acre (100 adult fish per hectare) in 2008 to about 152 adults per acre (377 adults per hectare) in 2016 (Hansen et al. 2019). Winter fluctuations are likely to increase erosion of the lakebed at lower elevations of about 2,051 to 2,056 feet and may affect forage fish production (Corps and Bonneville 2011).

Under the No Action Alternative, bull trout may experience greater predation and competition for food from walleye, northern pike, and lake trout. Walleye populations have been at a low level but are now expanding rapidly. From 2011 to 2017, relative abundance has doubled every 3 years (reference to be added prior to final). There is recruitment of walleye in Lake Pend Oreille as well as entrainment from upriver. Operations of Albeni Falls Dam and the lake may favor walleye and other warmwater fish during the time that bull trout subadults are migrating downstream into Lake Pend Oreille through the river/lake interface. Under current conditions, walleye populations are expected to expand and prey on sub-adult bull trout. Walleye also forage on kokanee, and therefore would compete with adult bull trout for this important food source.

Northern pike would also prey upon and compete with bull trout, but the actual effect under the No Action Alternative is undetermined. Studies in Montana show that northern pike eat bull trout (Muhlfield et al. 2008). Bull trout and westslope cutthroat trout make up about 5 percent of the diet of northern pike in upriver sites. Northern pike also prey on kokanee. While northern pike enter Lake Pend Oreille from upstream entrainment and in-lake recruitment, their numbers are still low and their future populations are undetermined.

Lake trout compete with bull trout for kokanee in Lake Pend Oreille. A lake trout suppression program in effect from 2006 to 2016 was successful in removing many lake trout from the lake and, consequently, kokanee populations have increased (Hansen et al. 2019). However, bull trout populations remained low and bull trout redd counts are down. Under the No Action Alternative, competition from lake trout is expected to continue at low levels in the lake.

There is a potential indirect effect to bull trout from hybridizing with brook trout populations. However, brook trout populations are primarily found in the tributaries, and only limited populations are found in the mainstem habitats.

Downstream of Albeni Falls Dam, non-native Northern pike and walleye have expanded their populations and may consume bull trout there. Northern pike are the apex predator in this system and are experiencing exponential population growth (reference to be added prior to final). Suppression efforts started in 2012 in Box Canyon reservoir, the first reservoir downstream of Albeni Falls Dam, have resulted in a 90 percent reduction in northern pike (reference to be added prior to final). Suppression efforts have also started at Boundary Dam, which is downstream of Box Canyon Dam. However, suppression efforts would not eliminate northern pike from the river, and the remaining fish could prey on entrained bull trout. This predation would not affect bull trout populations as any entrained bull trout would not be able to return upstream of the dam to spawn and would not survive the high water temperatures in the summer. Walleye have also expanded their populations in both Box Canyon and Boundary Reservoirs, but their numbers are still relatively low. Predation by walleye would have the same effect on bull trout as for northern pike under the No Action Alternative.

<u>Other Fish</u>

Under the No Action Alternative, kokanee would continue to be able to spawn, but their populations would be influenced by competition with opossum shrimp for food (zooplankton) coupled with predation by lake trout and other predatory fish species. The operation to manage winter lake elevations behind Albeni Falls Dam is, in part designed to support kokanee spawning and egg incubation in Lake Pend Oreille under the *Lake Pend Oreille Elevations for Kokanee and Bull Trout* measure. The intent is to lower the lake to its winter elevation before kokanee start spawning along the shoreline in November and December and hold it there through March to prevent dewatering of the redds during egg incubation. Flexible winter power operations (power peaking) result in changing lake elevations in the winter and may increase erosion of kokanee spawning habitat. While the modeling used for evaluating reservoir elevations cannot show power peaking operations, the current lake operations do not appear to adversely affect kokanee spawning or egg incubation. Relatively low numbers of kokanee would continue to be entrained through Albeni Falls Dam under the No Action Alternative. Entrainment most likely occurs during high flows but is not likely a large source of loss to the population of kokanee in Lake Pend Oreille (Bellgraph et al. 2015). Sampling by the Kalispel Tribe shows a limited number of kokanee downstream of Albeni Falls Dam. Kokanee have also been seen in the reservoirs behind Box Canyon Dam and Boundary Dam following high-flow events (personal communication, Bill Baker, WDFW).

Under the No Action Alternative, kokanee populations in Lake Pend Oreille would continue to be influenced by competition with opossum shrimp and predation by lake trout and other predators (e.g., Gerard rainbow trout, walleye, bull trout) (Corsi et al. 2019). Both opossum shrimp and kokanee feed on zooplankton, and high shrimp numbers reduce the amount of forage available to kokanee. At the same time, kokanee are also prey for lake trout, walleye, and bull trout. To maintain kokanee populations, predator suppression has been used to keep lake trout numbers down at Lake Pend Oreille, but walleye continue to increase. Opossum shrimp regulate kokanee population potential while predator populations appear to be the primary driver for kokanee populations within that potential in Lake Pend Oreille. Kokanee populations under the No Action Alternative are expected to continue remain at current levels in the foreseeable future assuming opossum shrimp populations remain low and predator management continues to be successful. Kokanee are expected to continue to provide forage for predators, including bull trout, in future years.

As with bull trout, the construction of Cabinet Gorge Dam blocked access to tributaries for westslope cutthroat trout in Lake Pend Oreille. This blockage resulted in a loss of genetics and habitat for the species. In 2016, trap-and-haul operations were implemented to capture adult westslope cutthroat trout at Cabinet Gorge Dam and transport them to upstream sites. As discussed above for bull trout, the design for a permanent fish trap at the dam was finalized in 2018 (Avista 2017). Under the No Action Alternative, westslope cutthroat trout from the lake would continue to have passage to their historic habitat above Cabinet Gorge Dam, either from the trap and haul program or the new permanent fish trap.

Similar to bull trout, an unknown number of westslope cutthroat trout are entrained through Albeni Falls Dam each year. Cutthroat are found relatively often below the dam and are isolated from their habitat as there currently is no trap and haul program at the dam to capture fish and return them to the lake. Cutthroat are cued to spawn when water temperatures reach about 10°C (Liknes and Graham 1988), or about May in Lake Pend Oreille. Entrainment is highest in May and June during the spring high spill season (Corps 2018) and coincides with when the fish are moving to spawning areas. Entrainment at Albeni Falls Dam is likely to continue and affect an unknown number of fish under the No Action Alternative.

As discussed above for bull trout, water temperatures between June and October are likely too hot for westslope cutthroat trout in the river section of Lake Pend Oreille as well as the river downstream of Albeni Falls Dam. Bear et al. (2007) found that water temperatures over 18°C are limiting for westslope cutthroat trout and the upper lethal temperature is about 20°C. Westslope cutthroat trout in the Pend Oreille River would also continue to be susceptible to predation from walleye and northern pike.

Walleye in Lake Pend Oreille spawn in the spring over cobble and gravel substrates when water temperatures reach at least 4°C (reference to be added prior to final). Under the No Action Alternative, water temperatures in Lake Pend Oreille would range from 3°C in February to 12°C in May (Appendix D). These temperatures and substrates would continue to support walleye spawning at Lake Pend Oreille under the No Action Alternative.

Stable water levels are also critical for walleye spawning success, as drawdowns during spawning would leave eggs and larvae dry. Walleye spawn when Lake Pend Oreille is filling, so the eggs and larvae would likely remain submerged under the No Action Alternative. Winter operations can fluctuate as much as 5 feet during early March and may affect a small portion of the walleye spawn. The effect on walleye spawning under the No Action Alternative is unknown, but elevated stable water levels may improve summer habitat for walleye.

Walleye fry (young fish that are capable of feeding themselves) are pelagic (living in open water) and feed on zooplankton. Reduce plankton numbers lead to reduced fry survival. Lake

Pend Oreille is classified as oligotrophic to mesotrophic (low to moderate productivity), and a moderate number of zooplankton were sampled, with increases in the last 8 years (reference to be added prior to final). Recent increases in walleye populations is evidence of lack of limitations to fry survival. Currently plankton numbers do not appear to be limiting for walleye. This would be expected to continue under the No Action Alternative.

Smallmouth bass spawning in Lake Pend Oreille is initiated when water temperatures reach about 13°C (Edwards et al. 1983). Under the No Action Alternative, water in Lake Pend Oreille would reach this temperature in mid-May. Egg development for smallmouth bass requires temperatures of 13°C to 25°C for normal growth. Surface water temperatures in Lake Pend Oreille currently reach 13°C in May and rise to over 20°C in July. This indicates the lake currently provides water temperatures that support smallmouth bass embryo development. This would continue under the No Action Alternative.

Pool elevation affects spawning, egg development, and fingerling survival for smallmouth bass. Water fluctuations during spawning and egg incubation (mid-May through June) can reduce recruitment if the water levels drop and dry up the nests. However, water elevations in Lake Pend Oreille generally increase from 2,057 to 2,062 feet during this period and therefore do not adversely affect smallmouth bass spawning or recruitment. This effect would continue under the No Action Alternative.

Pool elevations in Lake Pend Oreille from May through October may affect smallmouth bass fingerling survival. Water levels are generally raised from May to June, held constant until September, and dropped rapidly until mid-November. Under the No Action Alternative, this pattern of water level management in the lake may adversely affect smallmouth bass fry or fingerlings at the end of the rearing period in September and October by forcing the fish to leave nesting and rearing areas.

Pool elevations at Lake Pend Oreille can affect northern pike habitat availability. When the lake is at full pool, inlet and slough habitats that are optimum habitats for northern pike are inundated. When water levels drop, these habitats are no longer available. Pool elevations in Lake Pend Oreille are generally raised from May to July, held constant until September, and dropped rapidly through October. This operation would continue under the No Action Alternative and would result in lake levels that would support limited spring spawning and summer rearing habitat for northern pike.

High flows could affect entrainment at upstream reservoirs and move invasive northern pike from these reservoirs into Lake Pend Oreille. Flows from Cabinet Gorge Dam during the spring freshet (May and June) can be used as a surrogate for the risk of northern pike entrainment into Lake Pend Oreille with higher flows resulting in increased risk of entrainment. Median flows under then No Action Alternative for May and June would be 50,700 cfs and 55,600 cfs respectively. Under these flows, continued entrainment of northern pike into Lake Pend Oreille would be expected.

Mountain whitefish spawn in the Pend Oreille River below Albeni Falls Dam in October. Eggs and fry require sufficient stable winter flows to prevent desiccation and freezing. Under the No Action Alternative, median flows are 23,700 cfs in October to draft Lake Pend Oreille. In the winter, median discharge is 14,500 cfs to 16,600 cfs. As a result, an unknown number of whitefish eggs and fry are lost during this operation. Under the No Action Alternative, these losses would continue.

When non-native plants invade littoral zone habitats, changes in biotic and abiotic interactions often occur (Madsen 1998). Lake Pend Oreille has approximately 20,700 acres of littoral zone habitat for aquatic plant growth, or about 27 percent of the lake area. Eurasian watermilfoil is an invasive species that often grows in dense beds that can be responsible for reductions in DO, increases in water temperature, internal nutrient loading, reduced native plant richness, and reduced macroinvertebrate abundance and fish growth (Madsen 1998). Currently, milfoil beds are treated chemically to reduce their abundance and distribution. These treatments have resulted in a 90 percent reduction in the distribution of this invasive plant. Under the No Action Alternative, these treatments would continue and milfoil distribution is not expected to expand.

Game fish, particularly warmwater game fish, require stable water levels during spawning and rearing to prevent the desiccation of eggs or fry. The No Action Alternative operation would result in lake levels that would generally support spring spawning and summer rearing for warmwater game fish. Early winter drawdowns of Lake Pend Oreille can interrupt juvenile rearing and may reduce numbers of non-native game fish species like largemouth bass, pumpkinseed, and black crappie. Currently, water levels are dropped at Lake Pend Oreille in early September through November under the *Lake Pend Oreille Elevations for Kokanee and Bull Trout* measure. This drop would likely interrupt juvenile rearing and reduce successful recruitment in some years.

Gerrard or Kamloops rainbow trout are an important trophy fishery at Lake Pend Oreille. These fish grow to large sizes and require robust kokanee populations for adequate forage, as kokanee are the principal prey for adult rainbow trout. Under the current conditions, kokanee would continue to provide a forage base for large predators in this system. Kokanee have increased from about 40 adult fish per acre (100 adult fish per hectare) in 2008 to about 152 adults per acre (377 adults per hectare) in 2016 (Hansen et al. 2019).

In the river below Albeni Falls Dam, summer water temperatures are limiting to cool and cold water fish species. Salmonid species in particular often experience lethal temperatures in this reach of river. Only brown trout, the most temperature tolerant of salmonids, survive in Box Canyon and Boundary Reservoirs, but even they are still limited in their distribution. Currently, water temperatures reach approximately 22°C in late July. Under the No Action Alternative, temperatures would continue to reach lethal levels for most cold water fish in late July.

**Region B**

***Ongoing Existing Mitigation Programs***

In Region B, Bonneville F&W-funded hatchery programs include programs for white sturgeon, burbot, kokanee salmon, westslope cutthroat trout, and rainbow trout. For example, the Spokane Tribe, the Confederated Tribes of the Colville Reservation, and WDFW are collaborating to implement white sturgeon monitoring and conservation aquaculture in Lake Roosevelt. Spokane Tribe, Colville Tribe, and WDFW also implement projects to support resident redband trout and kokanee. With the use of Bonneville funds, the co-managers of Lake Roosevelt (Colville Confederated Tribes, Spokane Tribe of Indians and Washington Department of Fish and Wildlife) are working to address invasive fish. For example, they have removed 2,000 Northern Pike from the middle and upper sections of Lake Roosevelt since February 2018. Funding for these efforts have been provided by several other entities, including the Confederated Tribes of the Colville Reservation, Chelan Public Utility District, and Grant Public Utility District.

***Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam***

<u>Summary of Key Effects</u>

Flow, elevations, and water quality impact the quality of habitat for various resident fish species above, in, and downstream of Lake Roosevelt. For example, the Columbia River from the U.S.-Canada border would continue to support a white sturgeon population that spawns successfully but primarily relies on fish manager intervention. Sufficient flows and riverine length that allow for natural recruitment are experienced in only very few years. In Lake Roosevelt, retention time is a key metric for most fish species in Lake Roosevelt, driving the food web that supports the fish as well as influencing how many are entrained. Current levels of entrainment would continue. Lake elevations would continue to allow impaired tributary habitat access needed for spawning for redband rainbow trout and the portion of kokanee that spawn in tributaries, and reservoir operations would continue to result in some level of egg desiccation of the burbot spawn and the portion of kokanee that spawn on lake shorelines. The No Action Alternative would continue to support both wild and hatchery-raised kokanee, redband rainbow trout, and hatchery rainbow trout, as well as non-native warm water game species such as walleye, smallmouth bass, and northern pike. Under the No Action Alternative, adfluvial species are expected to continue to experience impeded migration to and from tributaries associated with varial zone effects.

Northern pike would likely continue to increase and invade downstream, with that rate of invasion slowed somewhat by suppression efforts. Rufus Woods Lake would continue to provide habitat for fish entrained from Lake Roosevelt and from limited production of shoreline spawning by some species, all influenced by high TDG levels.

Habitat Effects Common to This Fish Community

Peak outflows typically occur in late May to mid-June during the spring freshet. Higher winter flows can happen from winter rain events or drafting for larger spring water supplies. These peak outflows can influence the rate of entrainment from Lake Roosevelt into Rufus Woods Lake. TDG concentration in the Grand Coulee tailwater is also a concern for fish in Rufus Woods Lake. Under the No Action Alternative, daily average TDG would continue to exceed the state water quality standard of 110 percent saturation from early May through mid-August, and occasionally exceed 120 percent to 125 percent saturation in some years.

Retention time of water through the reservoir is a driving metric for the food web in Lake Roosevelt and influences the populations of several fish species as retention time is strongly correlated with entrainment (LeCaire 2000). Under the No Action Alternative, median retention time would range from about 40 to 50 days in the winter and early spring, dropping to as low as 21 days by June, then gradually increase over the summer to about 45 days at the end of August. September and October would have high retention times, with a median of 60 to 80 days. Entrainment of key species would continue, while habitat conditions would still support various life histories of these species in an impaired capacity.

Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely directly on the food source provided by the zooplankton production, and higher-level predators such as bull trout prey on these fish. Zooplankton are more widespread, more plentiful, and larger in body size when retention times are higher, and tend to be smaller bodied, swept out of the reservoir faster, and more concentrated near Grand Coulee Dam with a lower retention time. In this scenario, not only is there less food available to fish, but they also tend to follow the food source and crowd down toward the dam, becoming more susceptible to entrainment.

Bull Trout

Bull trout are rare in Lake Roosevelt and individuals are likely occasional strays from populations in river systems north of the U.S.-Canada border isolated from their spawning habitat (USFWS 2015). Bull trout are temperature-sensitive and would continue to use this reach for foraging, migration, and overwintering habitat until temperatures reach stressful levels at about 18°C (BioAnalysts 1998). Bull trout in Lake Roosevelt, although considered rare (USFWS 2015), are believed to exhibit adfluvial behavior, overwintering in the reservoir then moving into cooler tributaries as water temperatures in the mainstem increase. The timing of temperatures reaching levels that trigger bull trout migration would be similar to that in the past. High-flow years would continue to influence bull trout distribution through flushing more of them from the river near the U.S.-Canada border down into Lake Roosevelt, similar to the high flows of 1997, after which fish managers noticed an increase in bull trout in Lake Roosevelt (unpublished data). High flows also can cause entrainment out of Lake Roosevelt and into Rufus Woods Lake, as evidenced by past surveys that have captured occasional bull trout (Lecaire 2000).

Bull trout prey base would continue to fluctuate, as the fish they eat are sensitive to changes in productivity and location of zooplankton in Lake Roosevelt that is influenced by how long water stays in the reservoir. Bull trout are also sensitive to contaminants that are found in this region and would continue to bioaccumulate contaminants as a top predator (See Section 3.4, *Water Quality*).

Other Fish

In the Columbia River reach from the U.S.-Canada border to Lake Roosevelt, white sturgeon are typically able to spawn, but they rarely experience successful survival from larvae to juvenile life stages, and only in extremely high-water years. Successful recruitment appears to be dependent on a combination of flows exceeding 200 kcfs and water temperatures of about 14°C for 3 to 4 weeks in late June/early July (Howell and McLellan 2011 and Howell and McLellan 2014). The timing of these flows coinciding with lower reservoir levels can also increase sturgeon reproduction with the longer river habitat provided by a lower reservoir level. Other factors that would continue to influence sturgeon include: predation by fish that are favored by reservoir conditions if larvae are flushed into the Lake Roosevelt, and the uptake of contaminants such as copper closer to the U.S.-Canada border that can be flushed downstream into the reservoir by high flows. These higher flows would also continue to move larval sturgeon out of the area of higher copper concentrations. Under the No Action Alternative, recruitment of white sturgeon would continue to be a rare event supplemented by hatchery propagation, as larval sturgeon are captured and raised in hatcheries until they are past the time window where recruitment has been shown to fail at a high rate. Once these juveniles are released back into the reservoir, they continue to grow and survive well. The reservoir would continue to provide good conditions for growth and survival of these fish.

Wild production of native fish such as burbot, kokanee, and redband rainbow trout would continue to provide valuable resources in Lake Roosevelt. As described in the common habitat effects, these fish are the most sensitive to the effects of changing retention times. LeCaire (2000) estimated an average of over 400,000 fish annually are entrained, 30 to 50 percent of which were kokanee, primarily of wild origin. Rainbow trout were the second most entrained species. Entrainment of key species would continue at similar rates, while habitat conditions would still support various life histories of key species in an impaired capacity.

For tributary spawning species such as redband rainbow trout and a portion of the wild production of kokanee, tributary access at the right time of year is important. Reservoir drawdown in the spring creates barren tributary reaches through the varial zone, which would impede access to tributaries and the reservoir. Redband rainbow trout and the fluvial (that migrate up tributaries to spawn) portion of the kokanee population would continue to have impaired access.

Species such as kokanee and burbot that spawn on shorelines are susceptible to egg desiccation if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on shoreline gravels September 15 to October 15, and eggs incubate through February. Burbot tend to spawn successfully in depths provided by the No Action Alternative in the Columbia River and in Lake Roosevelt on shorelines near the Colville River in winter, with eggs incubating through the end of March (Bonar et al. 2000). Under the No Action Alternative, reservoir elevations begin to draft from near the full pool in January, with steeper drafts starting February through April, with larger water supply forecasts requiring deeper drafts. The portion of kokanee that spawn near the fall surface elevation would be more at risk, with a lesser effect on early spawners such that the fry emerge earlier in February. Fry sometimes also stay in the gravel and could become stranded as well. Burbot spawn later in the fall so would be less affected in dry years, with only about 3 feet of reservoir drop while eggs are in gravel, but they remain in gravel until the end of March when the median reservoir elevation is more than 30 feet deeper than the fall. Burbot spawn in the Columbia River above Lake Roosevelt and in the reservoir toward the upper end. These areas would be affected as the reservoir is drafted.

Kokanee are sensitive to water temperature, and during summer they are found at depths below 120 m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is very weakly stratified but does have suitably cool water at this depth along with suitable levels of DO. Lake whitefish and mountain whitefish also likely use this cool water in the summer.

Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish, crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all tolerate a wide range of environmental conditions and would continue to contribute to the fish community under the No Action Alternative, and continue to adversely impact native species via predation. The invasion downstream by northern pike is of concern because they are aggressive predators that threaten native fish, including anadromous salmonids. The Lake Roosevelt Co-Managers are actively suppressing pike populations using gillnets set by boats as soon as they can get on the water in the spring until the boat ramp becomes unusable at an elevation of 1,235 feet. Under the No Action Alternative, this occurs on April 15 in wet years, and would not occur at all in dry and average years. Additionally, outflows and retention time would continue to influence the entrainment and downstream invasion of non-native gamefish below Chief Joseph Dam where ESA-listed anadromous salmonids would be susceptible to predation by them.

Sterile rainbow trout are raised in net pens to provide additional recreational fishery as mitigation for the construction and operation of Grand Coulee dam. Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt would experience similar effects as their native counterparts except for spawning and early rearing effects. In addition, the net pen locations are situated where the water quality can be affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG, and their eventual recruitment to the fishery can be affected by retention time coupled with reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May. Under the No Action Alternative, the water quality at these locations from May 15 to June 15 would typically be suitable for rearing, with temperatures ranging from 10°C to 18°C and TDG from 101 percent to 125 percent, depending on water year conditions. The upper ends of these parameters under the No Action Alternative may cause some stress to net pen fish prior to their release. The average retention time would be about 13 to 33 days during this time, and the reservoir elevation would be highly variable, depending on the water year type driving reservoir operations. The operators strive to release these fish to coincide with the initiation of reservoir refill when outflows are reduced, which under the No Action Alternative is in early to mid-May, in order to reduce the risk of newly released fish being entrained out of the reservoir. Under the No Action Alternative, this typically would result in fish being released before water quality conditions become stressful in the net pens.

The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter drawdown periods. This lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short retention time and low productivity. High flows during late spring and early summer would continue to flush eggs and larvae from protected rearing areas. Peak outflows typically occur in late May to Mid-June during the spring freshet. TDG in the Grand Coulee tailwater is a concern for fish in Rufus Woods Lake. Under the No Action Alternative's *Spill Operations* and *Water Quality Plan for TDG and Water Temperature* measures, daily average TDG concentrations would continue to exceed the state water quality standard of 110 percent from early May through mid-August, and occasionally exceed 120 percent to 125 percent in some years. There are also net pens in Rufus Woods Lake, and TDG levels would continue to influence when and where these fish could be released.

***Chief Joseph to McNary Dam***

<u>Summary of Key Effects</u>

Key effects under the No Action Alternative for this reach of the Columbia River include elevated summer water temperatures; elevated TDG; hydropower dams that pose migration barriers, cause passage delays, or increase fish mortality; reductions in spawning and rearing habitats; and changes in flow patterns and temperatures that reduce spawning and recruitment success.

<u>Habitat Effects Common to All Fish</u>

Reservoirs in this reach of the Columbia River are a series of run-of-river impoundments that create slow-moving, river-like habitats. The reservoirs are mesotrophic (contain a moderate amount of dissolved nutrients) and provide ample zooplankton and aquatic invertebrates as forage for a variety of fish. This reservoir environment tends to favor non-native fish such as walleye, smallmouth bass, bluegill, perch, and crappie. Some native suckers also do well in these habitats, including bridgelip and largescale suckers. The temperatures would continue to be favorable for these cool and warmwater species. The substrate of these reservoirs is primarily silt and sand with some gravel and cobble habitats at dam tailraces. Large sections of the shoreline have been armored with riprap, providing suitable spawning habitat for many of these fish.

Water quality in the reservoirs would continue to be favorable for the current fish communities, with temperatures well within the tolerance of cool and warmwater fish. High flow events in the watershed can temporarily increase the amount of suspended sediment in the reservoirs.

However, under the No Action Alternative, most of the time suspended sediment levels would be less than 10 mg/L (see Section 3.4, *Water Quality*).

<u>Bull Trout</u>

Bull trout prefer water temperatures below 15°C, but adults can use temperatures up to 18 C. Although juvenile bull trout are not found in the mainstem in this river reach, temperatures above 15°C can limit their distribution (Selong et al. 2001; BioAnalysts 1998). Few bull trout are found in areas from the Chief Joseph Dam tailrace to the Okanagan River as the nearest spawning tributary is the Methow River 20 miles downstream. Adult and sub-adults exit the mainstem by early July returned to their spawning tributaries (Barrow et al. 2016; Nelson et al. 2012). Under the No Action Alternative, bull trout would continue to spawn in the tributaries, and both adults and subadults would continue to use the mainstem Columbia River and reservoirs for foraging, migration, and overwintering.

Effects to sub-adult and adult bull trout during passage at Mid-Columbia River dams include passage delays and mortality. Bull trout moving past Wells Dam may be delayed by about 5 days and may typically experience survival rates over 95 percent (Robichaud and Gingerich 2017). Under the No Action Alternative, bull trout would continue to pass all the dams in this reach except Chief Joseph and would be expected to continue to experience high survival rates.

TDG levels from spill under the No Action Alternative, including through the *Spill Operations* and *Water Quality Plan for TDG and Water Temperature* measure, may adversely affect an unknown number of bull trout in the reservoirs. As discussed in Appendix D, *Water Quality*, TDG exceeds 110 percent on 11.3 percent of all days from October through July at Chief Joseph Dam and 26 percent of all days during this time at McNary Dam. Under the No Action Alternative, there continues to be a minor risk for adverse effects from TDG on bull trout May through July in this reach of the river.

<u>White Sturgeon</u>

White sturgeon spawning habitats are limited to fast water areas below run-of-river dams and the Hanford Reach. Under the No Action Alternative, an unknown number of juvenile white sturgeon would continue to be entrained from this river reach.

White sturgeon generally initiate spawning in the late spring when water temperatures reach 10°C to 12°C during the peak or descending limb of the hydrograph. Higher flow years have better spawning and recruitment success. Currently, white sturgeon recruitment is rare. The lack of spawning habitat and high lows to induce spawning are cited as the cause for this lack of recruitment (Hildebrand et al. 2016).

Currently, an unknown number of white sturgeon succeed in passing downstream of dams on the Columbia River. Sturgeon populations in upper basins currently act as source populations for downstream recruitment. Under the No Action Alternative, these fish would continue to be limited to downstream dam passage.

Elevated water temperatures can have adverse effects on white sturgeon. Temperatures over 20°C can limit egg survival (Wang et al. 1985), and in some years, a combination of low flows, elevated summer temperatures, and low DO levels have led to white sturgeon mortality (IDFG 2008). During 2015, elevated water temperatures interacted with large sockeye runs to increase white sturgeon mortality. Sturgeon gorged on decomposing sockeye while water temperatures were near 22°C and were unable to metabolize these fish. Under current conditions, mean high temperatures greater than 21°C would occur nearly 10 percent of the year at McNary Dam and only about 1 percent of the year at Priest Rapids Dam. Under the No Action Alternative, extreme low-flow or high-temperature years would continue to result in white sturgeon mortality events.

Elevated gas or TDG can have adverse effects on white sturgeon. Larval sturgeon may experience GBT with an elevated TDG of nearly 120 percent and may have up to 50 percent mortality at a TDG of 130 percent and greater (Counihan et al. 2000). The magnitude of effects from an elevated TDG may be offset if fish are able to compensate by moving to greater depths where TDG saturation is reduced. Currently, TDG values over 118 percent occur on less than 1 percent of all days in this reach of the river. Under the No Action Alternative, TDG is not expected to adversely impact white sturgeon.

<u>Other Fish</u>

Walleye require cold water over clean gravel or cobble substrates for successful spawning. Currently, water temperatures in the Columbia River are suitable for walleye spawning from early to mid-spring, and there is no shortage of suitable substrates for spawning in the mid-Columbia River reach.

In addition, walleye fry require stable backwater habitats for rearing until they are able to swim proficiently. Operations that fluctuate water levels can entrain walleye fry from the safety of these critical backwater habitats. Current operations create a flow and temperature regime that would continue to support walleye growth and recruitment in these habitats on approximately 65 percent of days in the rearing period. Under the No Action Alternative, walleye would continue to have adequate spawning and rearing habitats.

Smallmouth bass require stable or rising water levels and temperatures to induce successful spawning and rearing. Water temperatures between 12°C and 15°C trigger spawning activity, while stable water levels prevent the desiccation of eggs and fry. In addition, an influx of cold water, once spawning has begun, can cause males to abandon nests, resulting in recruitment failure. Current operations provide stable water levels and temperatures in most years. Modeling suggests spawning temperature of 12°C would be reached on May 3 in an average year.

Cold water temperatures reduce smallmouth bass activity. In fact, when water temperatures drop below 10°C, smallmouth bass become inactive and seek shelter (Edwards 1983). If temperatures remain below this level for too long, adult fish would not survive. Currently, at McNary Reservoir, smallmouth bass would be inactive for approximately 161 days. Under the

No Action Alternative, water temperatures would continue to provide adequate growth and survival for smallmouth bass populations.

Smallmouth bass are visual predators, and increased turbidity can limit growth and feeding success (Sontag 2013). In addition, highly turbid waters can displace smallmouth bass fry and limit recruitment (Edwards 1983). Currently, elevated turbidity is limited to spring runoff and large rain events. The remainder of the year, water clarity is good with a suspended sediment measure of about 2 ppm. Under the No Action Alternative smallmouth bass foraging would be limited in high spring runoff and large rain events. Turbidity is not expected to limit recruitment for this alternative.

Passage success for most fish at CRS projects in this reach of the Columbia River is unknown. Currently, upstream passage would be difficult for some species, while downstream passage would be associated with some unknown level of survival. Under the No Action Alternative, passage success is not expected to change. Some unknown portion of each species would continue be entrained or would pass upstream through fish ladders.

Elevated summer water temperatures limit the distribution of fish species. Currently, upstream reservoirs have cooler water temperatures relative to dams lower in the reach by about 2 degrees Celsius on average. This slight difference in water temperatures can affect important changes in the fish community. Under the No Action Alternative, upstream reservoirs near Chief Joseph Dam would continue to reduce growth and productivity of warmwater fish species relative to McNary Dam and the Hanford Reach.

The Hanford Reach is the last remaining free-flowing reach of the Columbia River in the United States above Bonneville Dam. However, current operations above the Hanford Reach can have detrimental effects to resident fish communities. Water flows can change such that river elevations in the Hanford Reach can fluctuate by as much as 3 m in 6 hours, which has the potential to dewater aquatic habitats and reduce productivity in this reach of river. Under the No Action Alternative, the Hanford Reach would continue to be an important refuge for native resident fish species but would experience water level fluctuations that may limit productivity of this reach.

**Region C**

Region C consists of the Snake River Basin. Resident fish analyses in this region are discussed in one section, including the mainstem Snake River, Clearwater River, and Dworshak Reservoir.

***Ongoing Existing Mitigation Programs***

In Region C, Bonneville F&W-funded projects with the Nez Perce Tribe in the Lochsa watershed are working to improve habitat for resident fish. Idaho Department of Fish and Game are also improving habitat for Yellowstone cutthroat trout. Riparian, wetland, and instream habitat restoration in Region C that targets anadromous fish or wildlife species also can improve habitat conditions for resident fish species. Through its F&W Program, Bonneville funds many habitat restoration actions that benefit multiple species. For example, the Shoshone-Bannock Tribes of the Fort Hall Reservation have enhanced over five miles of the Yankee Fork Salmon River to promote anadromous and resident fish habitat.

Another example is the Dworshak Dam Resident Fish Mitigation, which boosts Kokanee Salmon abundance, thereby providing forage resources (eggs, fry, sub-adults) for bull trout, cutthroat trout, and other resident fish species in the blocked area of the North Fork Clearwater River.

***Snake River Basin***

Summary of Key Effects

Kokanee would continue to use Dworshak Reservoir during most of their life history and return to the tributaries to spawn. Reservoir elevations in the fall would provide access to about 90 percent of their spawning areas. The chance of kokanee being entrained through the dam would be low, with the highest risk in late February and all of March. Dworshak Reservoir would also continue to provide habitat for smallmouth bass.

Under the No Action Alternative, the Snake River Dams would continue to fragment white sturgeon habitat by limiting passage upstream and downstream. Populations of white sturgeon in the Ice Harbor, Lower Monumental, and Little Goose Reservoirs would be expected to continue to decline from lack of recruitment (young fish surviving past the larval stage and up to 1 year of age). Habitat conditions for white sturgeon would continue to be of limited adequacy in the reservoirs under the No Action Alternative. Water temperature would be within the range needed for spawning and rearing. Flows and substrate in the tailraces of the four Snake River Dams would provide suitable habitat for spawning and rearing. Water quality would be sufficient to support white sturgeon.

The No Action Alternative would continue to provide reservoir conditions that favor non-native fish such as walleye and smallmouth bass. No change in resident fish populations or their use of the Snake River Basin would be expected, except for walleye. Walleye have been expanding their range upriver in the reservoirs and are now found as far upstream as Little Goose reservoir. Two crustaceans, Siberian prawns and opossum shrimp, are increasing their populations in the lower Snake River Reservoirs and may provide an additional food source for resident fish. This population trend may continue under the No Action Alternative.

Habitat Effects Common to this Fish Community

The Snake River Reservoirs are a series of run-of-river impoundments that create a long run of reservoir and slow-moving river habitat. This reservoir environment tends to favor non-native fish such as northern pikeminnow, walleye, smallmouth bass, bluegill, perch, and crappie. Some native suckers also do well in these habitats, including bridgelip and largescale suckers. Generally, the temperatures would continue to be favorable for these warmwater species to be abundant and some may increase in population and distribution. Much of the substrate in the reservoirs is sand or cobble, and large amounts of shoreline have been armored with riprap, providing suitable spawning habitat for these fish.

Water quality in the reservoirs would continue to be favorable, with temperatures well within the tolerance of warmwater fish, and consistently favorable levels of DO. High-flow events in the watershed can temporarily increase the amount of suspended sediment in the reservoirs. However, under the No Action Alternative, most of the time, suspended sediment levels would be less than 10 mg/L (Appendix D).

<u>Bull Trout</u>

Under the No Action Alternative, low numbers of bull trout would continue to use the mainstem of the Snake River for foraging, migration, and overwintering and some movement between populations would continue. Bull trout migrate foraging, migration, and overwintering habitat in November and December, then return to tributaries in March through May. Lower Monumental and Ice Harbor Reservoirs provide a connection between the Tucannon and Walla Walla Subbasins, with some Tucannon fish moving downstream through the Snake River to the Columbia River, then up the Walla Walla River. Larger bull trout that do use the Snake River are the drivers of the population as they are generally more productive. Potentially, the loss of the larger, fluvial fish (fish that spawn and rear in tributaries, then migrate to a lake) from the upstream community could drive a change in that community structure.

Bull trout movement through the basin would continue to be primarily downstream rather than upstream under the No Action Alternative. Low numbers of fish would continue to be entrained at the Snake River Dams and passed downstream either through the turbines or through the juvenile salmon bypass systems. This movement at the dams is primarily between April and June when the fish are moving out of the reservoir system to avoid higher water temperatures. Even though the fish ladders at the dams were not designed to pass bull trout (Barrows et al. 2016), low numbers of bull trout would be expected to continue to use the fish ladders to move upstream to other reservoirs and the upper basin. Bull trout movement through the fish ladders on the lower Snake River Dams would continue to be temporarily halted when the ladders are closed for maintenance in January and/or February.

Under the No Action Alternative, migration of bull trout to the North Fork Clearwater River Subbasin from the rest of the Clearwater Basin would continue to be blocked by Dworshak Dam, as the dam has no fish ladders or other means of passing fish upstream. However, bull trout in Dworshak reservoir would continue to have access to most spawning areas in tributaries above the dam. The reservoir drawdown does not eliminate the ability of fish to access the free-flowing reach of the North Fork Clearwater above the reservoir. The timing of reservoir refill coincides with the time in May and June that adult bull trout begin their upstream migration (Hanson et al. 2006) and would continue to provide connectivity between the reservoir, tributaries, and the rest of the North Fork Clearwater Basin under the No Action Alternative.

Water temperature would remain cold enough for low numbers of bull trout to continue to use the Snake River Reservoirs and the Snake and Clearwater Rivers during much of the time they are most likely to be present, primarily November through May (Barrows et al. 2016). Under the No Action Alternative, the water quality modeling shows water temperatures in the lower Snake Reservoirs are expected to exceed 15°C 0.3 percent of the time from November through May, resulting in a negligible effect on bull trout.

Elevated TDG levels from spill may adversely affect an unknown number of bull trout in the reservoirs by degrading habitat in the mainstem Snake River and causing habitat loss. Bull trout effects from an elevated TDG during spill was determined using the number of days that TDG would be over 110 percent between November and June, the months bull trout are most likely to be in the Snake River reservoirs. Under the No Action Alternative, 37.3 percent of days November through June would exceed 110 percent TDG through the *Spill Operations* measure. Suspended sediment and DO would continue to be within tolerance levels for bull trout.

Forage for migrating bull trout in the Snake River would continue to be adequate in the lower Snake River under the No Action Alternative. The Snake/Clearwater River system supports healthy populations of forage fish.

The potential for predation on bull trout in the rivers and reservoirs would also be reduced under the No Action Alternative because bull trout use these areas in the winter when the water is generally cold. Warmer water temperatures generally are associated with higher risk of predation. Predators such as catfish, northern pikeminnow, walleye, and smallmouth bass are more active when water temperatures are relatively warm (greater than 15°C).

<u>White Sturgeon</u>

Spawning behavior by white sturgeon in the Snake River Basin is not expected to change under the No Action Alternative. Spawning behavior is cued by high water velocities during the period just after peak runoff and by adequate temperatures (Hildebrand et al. 2016). Spawning is currently limited in most areas of the Snake River Reservoirs because water velocities are not adequate to cue spawning. However, some spawning occurs near the dams in the tailraces where velocities are higher. The mean water velocity to support spawning needs to be greater than or equal to 2.6 feet/second, but the average velocity for the year under the No Action Alternative would be about 0.4 feet/second.

Water temperatures in the lower Snake River would be suitable for sturgeon spawning under the No Action Alternative. Spawning in the Snake River occurs between April and July and when water temperatures are between 12°C and 18°C (Hildebrand et al. 2016). Modeling results for the April 15 and June 30 spawning period under the No Action Alternative indicate water temperatures would be above 18°C for 8.2 percent of the time. This indicates water temperatures would be within the acceptable range for most of the spawning period.

Water temperatures in the lower Snake River would also be suitable for egg incubation under the No Action Alternative. Water temperature is critical for white sturgeon egg incubation. Temperatures outside of the 8°C to 18°C range show reduced egg survival, with mortality occurring when temperatures are greater than 20°C (Lepla and Chandler 2001). Modeling results for the spawning period between April 15 and June 30 indicated water temperatures would be below 8°C for 0.3 percent of time, and above 18°C for 8.2 percent of the time).

Modeling results also showed water temperatures above 20°C for 2.7 percent (168 out of 6,160 days) during the spawning period. This indicates water temperatures would be within the acceptable range for egg incubation during the spawning period.

The Snake River would continue to provide limited rearing habitat for the yolk sac larvae under the No Action Alternative. The preferred habitat for these larvae is gravel and cobble substrates with interstitial spaces in which to hide (Hildebrand et al. 2016; McAdam 2012). This type of substrate is limited in most areas of the reservoirs. However, previous surveys of the Snake River Reservoir substrate have shown that gravel and cobble habitat occurs primarily in the tailraces of each of the Snake River Dams. These tailrace areas would continue to provide potential habitat for the yolk sac larvae under the No Action Alternative.

Snake River Reservoir trophic production would continue to provide adequate forage for larval (less than 1 year of age), juvenile (1 to 7 years of age), and adult white sturgeon under the No Action Alternative. All of food organisms for each life stage are found in adequate quantities in the reservoirs and would not limit the sturgeon population. The increasing number of Siberian prawns and opossum shrimp in the reservoirs would provide an additional food source for sturgeon.

Migration of white sturgeon through the lower Snake River would continue to be hindered by the dams due to the limited to no passage at the dams (though a few have been observed moving downstream). Sturgeon do move between Lower Granite Reservoir and the free-flowing section of the river above the reservoir. There appears to be a gradient of reduced abundance of juvenile sturgeon with increased distance from Lower Granite Dam. This suggests that many of the white sturgeon in the lower Snake Reservoirs could have been entrained through the dams (Hildebrand 2016; Devore 1999). It is also possible that juvenile sturgeon move downstream seeking food sources.

Under the No Action Alternative with its *Spill Operations* measure, TDG levels at the dams would have an adverse effect on white sturgeon for about 10 days, primarily in June and July. Young white sturgeon are sensitive to TDG levels (McGrath 2006; Weitkamp 2008; Hildebrand 2016; Counihan et al. 1998). TDG levels of 118 percent alters buoyancy in larval white sturgeon, which make them more prone to predation. TDG levels of 130 percent cause about 50 percent mortality. Modeling shows that under the No Action Alternative, TDG levels would be greater than 120 percent for 809 of 9,760 days from April 1 through July 31, or 8.3 percent of that period, with a high of 136 percent TDG. Suspended sediment and DO levels would remain favorable for sturgeon.

In-river contaminants are not likely to affect white sturgeon populations under the No Action Alternative. Sturgeon are highly sensitive to in-river contaminants such as selenium and methylmercury, which can have sublethal effects (Coffey 2014; Little 2014 Wan Ming 2014). Through the portion of the Snake River downstream of the confluence of the Snake and Clearwater Rivers, these contaminants are not expected to be found in the sediments in concentrations that would affect sturgeon.

Predation and harvest would have little effect on white sturgeon under the No Action Alternative. There are no known adult predators of sturgeon in this subbasin (several fish species prey on sturgeon eggs and juveniles, including walleye, smallmouth bass, and sculpin). Harvest is not allowed on the lower Snake River except below Ice Harbor Dam, but catch-and-release recreational fishing on sturgeon is allowed. The estimated mortality of this fishing is about 3 percent, which may have a minor effect on white sturgeon populations (Robichaud et al. 2006).

<u>Other Fish</u>

Dworshak Reservoir and the Clearwater are inhabited predominantly by cold water species such as kokanee bull trout, westslope cutthroat trout, redband rainbow trout, as well as the cool-water-favoring smallmouth bass. Westslope cutthroat occur in Dworshak Reservoir and the Clearwater Basin, but would not likely be affected by the MOs. They are not addressed further.

Redband rainbow trout are divided into two subgroups. Trout that are anadromous are considered to be steelhead. Those that are residents of the interior Pacific Northwest are redband or resident rainbow trout (Muhlfeld et al. 2015). Within the Snake River Basin, redband rainbow trout that interact with the projects are classified as steelhead and are addressed in the four steelhead sections (Upper Columbia River, Snake River, middle Columbia River, and Lower Columbia River steelhead), under Anadromous Fish, under Section 3.5.2.2, No Action Alternative. Those redband rainbow trout that are in the tributaries are not likely to be affected by actions at the projects and are not addressed further.

In the Snake River Subbasin reservoirs, kokanee are found only in Dworshak Reservoir, where they were introduced in 1972. Since their introduction, kokanee have become the primary fishery in the reservoir. Kokanee spawning normally occurs in the fall and would continue along the tributaries to Dworshak reservoir under the No Action Alternative. Spawning areas are inaccessible when the reservoir level is below elevation 1,450 feet during September and October. However, under the No Action Alternative the mean water elevation in the reservoir in September and October would be at elevation 1,521, therefore kokanee would have access to about 90 percent of their spawning areas in most years.

Entrainment of kokanee at Dworshak Dam would continue to be of concern under the No Action Alternative if the Corps needs to release large volumes of water in the winter or spring. Entrainment occurs when water is released from the dam and fish in the forebay are pulled through the dam along with the water. Entrainment at Dworshak Dam is mostly a problem in the winter when kokanee congregate near the dam, making them susceptible to high discharge, as opposed to other times of the year when they are using the upper parts of the reservoir near the spawning areas. Kokanee entrainment is positively related to discharge during January through March (Bennett 1996). However, the use of lower gates to release water away from kokanee populations has likely reduced the effect. Historically, the Corps has released water in the fall and winter to make room for flood storage. Large numbers of kokanee have been removed from the reservoir during high winter releases, which can result in lower populations that can take several years to rebuild. Entrainment has been reduced in recent years now that the Corps starts releasing water in the summer for flow augmentation and cooling of the lower Snake River and does not wait until winter to start to release water (personal communication, Paul Pence, April 29, 2019). Modeling results for the No Action Alternative show median discharges from Dworshak would remain low for January through March, with a maximum flow typically near powerhouse capacity. The highest risk would be in late February and the entire month of March. High water years have a greater risk of entrainment. Median years have risk in late March.

Smallmouth bass also inhabit Dworshak Reservoir. Dworshak Reservoir provides smallmouth bass spawning habitat along the shoreline, but the timing of the reservoir operations could interrupt the spawning/rearing cycle under the No Action Alternative. Smallmouth bass spawn in the spring (Webster 1954, as cited in Wile 2014). Males move into spawning areas when the water temperature reaches about 16°C (Wile 2014). The optimum temperature range for spawning is 12.8°C to 21°C (Edwards et al. 1983). Dworshak reservoir start to refill in April or early May, usually reaching full pool elevation of 1,600 feet by July 4. After July 4, water releases from the reservoir for flow augmentation and cooling water lower the reservoir to elevation 1,520 by September. Water temperatures under the No Action Alternative would not reach 16°C, the temperature at which smallmouth bass spawn, until about May 7. In most years, smallmouth bass would be able to spawn, and the fry should be able to leave the nesting area before the drawdown would desiccate the nest. In Dworshak reservoir, smallmouth bass feed on several fish species, including kokanee. The abundance of kokanee contributes to the growth of smallmouth bass in the reservoir (IDFG 2018).

In the lower Snake River Reservoirs and river reaches, several non-native fish would continue to dominate the resident fish community. Native mountain whitefish would continue to be found in the tributaries. Downstream passage past the dams would be possible. The Corps has found mountain whitefish in the juvenile bypass system in varying numbers at Lower Monumental Dam. The Corps recorded 521 fish in the bypass in 2017 and 235 fish in 2018.

Northern pikeminnow prefer slow-moving water in lakes and rivers with gravel or soft sand substrates (Gadomski et al. 2001), that would continue to be provided by the lower Snake River. Northern pikeminnow prefer temperatures of 16-22°C but are found in warmer waters (Brown and Moyle 1981). Temperature modeling for the No Action Alternative predicted that water temperatures in the tailrace of Ice Harbor Dam would reach 14°C around June 5 and would be above 15°C for 88.7 percent of the modeled days (10,826 days) from June through October. Therefore, water temperatures would continue to support successful spawning and rearing by Northern pikeminnow. No Action Alternative conditions would continue to provide adequate food sources for larval and juvenile Northern pikeminnow. Because Northern pikeminnow rear in the gravels in the tailraces of the dams where the water is shallower and the TDG levels are higher, there is the potential for the juveniles to be adversely affected. Water quality modeling indicated TDG levels would be above 120 percent for 809 out of 9,760 modeled days (8.3 percent of the time) in April through July at Ice Harbor with a high of 136 percent TDG. The water quality plots show the majority of the days would be in June and July.

Under the No Action Alternative and its *Spill Operations* measure, elevated TDG would have an elevated adverse effect on northern pikeminnow for about 10 days, primarily in June and July. Occasional high-flow sediment events may occasionally affect northern pikeminnow, but most of the time would be low. DO and suspended sediment would be within tolerances for northern pikeminnow.

Walleye are abundant in Ice Harbor and Lower Monumental Reservoirs and are increasingly found in Little Goose reservoir. Adults have been found in Lower Granite Reservoir. Under the No Action Alternative, the reservoirs would continue to provide adequate spawning habitat and forage that would support large numbers of walleye. The lower Snake River Reservoirs would also continue to provide adequate conditions for walleye spawning. Temperature modeling for the No Action Alternative shows that water temperatures in the lower Snake River Reservoirs would be suitable for walleye spawning from mid-February to mid-April, which is within the period when walleye spawn. The lower Snake River Reservoirs would continue to provide adequate water temperature conditions for rearing walleye fry under the No Action Alternative for at least part of the year. Water temperatures would be too cold for optimum growth of fry when they first hatch, but conditions would improve and best growth would occur after mid-June. High or variable water velocities in rearing areas during April and May can transport juveniles to unsuitable habitats (reference to be added prior to final). Modeling for the No Action Alternative shows median flows in the lower Snake River during this time would be relatively high. Successful rearing would occur at limited sites with adequate shelter from high flows. Adequate resting and feeding habitat for adult walleye is currently provided by the lower Snake River reservoirs. Adults prefer deeper water offshore habitat during daylight hours, then move into shallow water feeding sites along the shoreline at night (reference to be added prior to final). These types of habitat are not limited in the lower Snake River and would continue to be available under the No Action Alternative.

Smallmouth bass would also continue to flourish. Much of the substrate in the reservoirs is sand or cobble, and large amounts of shoreline have been armored with riprap (large rock), which would continue to provide cover for nests. Water temperatures in the lower Snake River would continue to be conducive for embryo development under the No Action Alternative. Smallmouth bass prefer temperatures ranging from 12 to 31°C (Ferguson 1958; Barans and Tubb 1973; Reutter and Herdendorf 1974), and lower temperatures would be less favorable for smallmouth bass. Water flows and temperatures would be suitable for smallmouth bass fry in the lower Snake River in mid to late summer under the No Action Alternative. Conditions would be best for fry in July and August as there would be low flows and relatively high water temperatures. Temperatures in the lower Snake River, as represented by Little Goose Reservoir, would exceed 21°C, and thereby provide ideal growth conditions, for only about 52 days per year (14.3 percent of all days). However, the high numbers of smallmouth bass in the reservoirs show this is not currently limiting the population. Smallmouth bass growth would continue to increase in May to June. Water temperatures in the lower Snake River Reservoirs would affect the activity level of adult smallmouth bass under the No Action Alternative. Under the No Action Alternative, water temperatures in the lower Snake River Reservoirs, as represented by Little Goose Reservoir, would reach 10°C starting about April 25 and stay above that temperature until about November 12. Temperatures would be below 10°C for about 168 days out of the year, or 46.0 percent of the year. This would result in adults being inactive during the late fall through early spring, and then becoming active starting in May.

DO, turbidity, and suspended sediment levels in the lower Snake River under the No Action Alternative would be within acceptable limits for smallmouth bass growth and survival most of the time. High turbidity can limit growth and feeding success of adult smallmouth bass as they are sight feeders and turbidity can limit their ability to locate prey. Sontag (2013) found a drop in smallmouth bass predation during flows with high turbidity. Turbidity in the lower Snake River is usually less than five Nephelometric Turbidity Units and rarely exceeds 200 Nephelometric Turbidity Units but could limit feeding success of smallmouth bass during early runoff in some years under the No Action Alternative.

**Region D**

***Ongoing Existing Mitigation Programs***

Bonneville's F&W Program in Region D includes projects that focus on bull trout and sturgeon. Bonneville has worked with the Confederated Tribes of the Warm Springs to monitor the status of bull trout in the Lower Deschutes basin. ODFW, WDFW, and CRITFC have been conducting long-term monitoring of white sturgeon populations on the Lower Columbia. Floodplain, wetland, and instream habitat improvement that targets anadromous fish or wildlife also improves habitat conditions for resident fish species.

***McNary Dam to the Columbia River Estuary***

<u>Summary of Key Effects</u>

Bull trout would continue to migrate upstream and downstream through the Columbia River System in limited numbers and seek thermal refugia (i.e., cold water habitat) available at the mouths of tributaries. White sturgeon would continue to successfully reproduce in years with adequate flow and temperature conditions.

<u>Habitat Effects Common to this Fish Community</u>

Outflows from McNary Dam Reservoir would influence some of the fish relationships described in this section. Peak spring flows affect habitat maintenance for some species. Modeled mean monthly outflows for the No Action Alternative are as follows:

- April: 191,600 cfs
- May: 260,300 cfs
- June: 285,020 cfs
- July: 197,900 cfs

Other flow parameters referred to in this section refer to outflows of McNary Dam that are indicative of flows downstream through the other projects.

Bull Trout

Bull trout are known to use the mainstem Columbia River to move between tributaries and have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et al. 2016). Water temperature is the most important habitat factor for bull trout in the mainstem Columbia River. Fluctuations in the Bonneville Dam pool could suppress vegetation on the delta at the mouth of the Klickitat and Hood Rivers, making bull trout more susceptible to predation when trying to access tributaries or use the mouth of the tributary for thermal refugia (personal communication, Bill Sharpe, Yakama Nation, 2019). Under the No Action Alternative, bull trout would continue to use the mainstem Columbia for migration between tributaries, as well as tributary mouths for passage and thermal refugia.

Adult bull trout move downstream during fall and overwinter in reservoirs (October to February; Barrows et al. 2016). Although bull trout successfully move between areas on the mainstem, their migration can be delayed at the dams. Passage through turbines can cause injury or mortality.

Bull trout are subject to bird predation, as evidenced by recovery of PIT tags on bird colonies (Barrows et al. 2015). Predation on bull trout would continue to occur under the No Action Alternative.

White Sturgeon

White sturgeon occur throughout the lower Columbia River from McNary Dam to the estuary, but abundance is highest below Bonneville Dam and decreases further upstream (ODFW 2019). Factors important for white sturgeon relative to the operations of the CRS include flow rates, water quality (temperature and TDG), predation, and habitat conditions. To compare habitat characteristics important for white sturgeon to the MOs, the modeled median monthly outflows and modeled temperatures at Bonneville Dam (based on the period of record) were examined for the relevant time periods and documented. The Bonneville Dam tailrace was used as an indicator, because the highest abundance numbers for white sturgeon occur from Bonneville Reservoir downstream to the estuary. Under the No Action Alternative, the Bonneville Dam tailrace would provide suitable spawning and incubation temperatures from mid-April to mid-July. Model results indicate suitable spawning temperatures occurring from a range of 48 days (2015) to 74 days (2012). The number of days with optimal embryo incubation (12°C to 14°C) would range from 8 days (2013) to 27 days (2011). In years of low-flow conditions, water temperatures could increase beyond the suitable range by early June, resulting in little or no recruitment.

Flows for successful sturgeon spawning and recruitment were analyzed based on the McNary Dam tailrace. Since lower Columbia River Dams are run-of-river, the outflow at McNary Dam correlates with the outflows at John Day, The Dalles, and Bonneville Dams. Flows of at least 250 kcfs from April 1 to July 31, coupled with suitable temperatures, provide favorable spawning and rearing conditions. Flows would continue to be adequate for sturgeon spawning and recruitment in most of the April to June timeframe in high-flow years, but only about half of the time in average flow conditions. Low-flow years would likely not provide sufficient time with suitable flows for recruitment to occur. In years of extreme low flows and warm water, higher-than-typical adult mortalities have been documented (personal communication, O. Langness 2019).

White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse substrates (Parsley et al. 1993). McCabe and Tracy (1994) concluded that spawning in the Bonneville Dam tailrace occurred on days with mean discharges from Bonneville Dam, ranging from 120 kcfs to 371 kcfs. Model results for the current analysis indicate that flows are always higher than 120 kcfs from April through July.

Lack of effective upstream white sturgeon passage for all age classes decreases the connectivity of the population (Parsley et al. 2007). Under the No Action Alternative, disconnection in populations would continue. White sturgeon are known to pass through the dams, although this only occurs in the downstream direction (Warren and Beckman 1989). The spillway is the most likely source of downstream passage.

Turbine units at Bonneville Dam can cause injury and mortality in juvenile and adult sturgeon due to blade strikes. This has been reduced by the slow-roll procedure for starting up turbines. Under the No Action Alternative, a small amount of injuries or mortalities could occur, but the incidence would be greatly reduced by continuing to implement the slow-roll start-up procedure.

White sturgeon larvae are adversely affected by TDG. Studies have shown high rates of altered buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al. 1998).

Changes in a pool or tailrace elevation can affect juvenile white sturgeon through stranding in shallow water. Under the No Action Alternative, pool elevations in the reservoirs would remain consistent.

Pinnipeds, mainly Steller sea lions, are known to prey on white sturgeon in the Bonneville Dam tailrace. Stellar sea lions have increased their abundance and seasonal presence (Tidwell et al. 2019). Pinnipeds may have altered the spawning of white sturgeon in the Bonneville Dam tailrace as they attempt to avoid predation. ODFW has observed direct predation on sturgeon and harassment of spawning sturgeon by Steller sea lions, which can lead to stress and aborted spawning activity (personal communication, Chapman 2019). Resident fish such as sculpin, walleye, and smallmouth bass are predators of embryo and age-0 white sturgeon. Under the No Action Alternative, predation would continue to affect early life stages of white sturgeon.

Reservoirs in the lower Columbia have higher rates of sedimentation, and invasive aquatic plants could reduce habitat value for sturgeon through changes in predation, food availability, and suitability for invasive species. This trend would be expected to continue under the No Action Alternative.

<u>Other Fish</u>

Within this reach of the lower to middle Columbia River, at least 45 resident fish species occur, of which over half are native (NPPC 2001; Ward et al. 2001). In addition to white sturgeon and bull trout (discussed previously), Northern pikeminnow, walleye, smallmouth bass, native minnow species, and estuarine fish assemblages occur within this reach. Walleye, smallmouth bass, and other non-native gamefish are warmwater fish species, and channel catfish are present in the lower CRS.

Habitat components important for these resident fish communities include flow rates, water quality, and food availability. The mainstem dams are barriers to upstream movements by most resident fish. However, resident fish are known to pass through fishways at the dams. TDG levels could have adverse effects on any of the resident fish species. ODFW sampling during spring, when higher TDG rates occur, did not observe GBT in pikeminnow, smallmouth bass, or walleye.

Northern pikeminnow are a part of the resident fish community and are important in their role as predators of salmon and steelhead. Analysis of pikeminnow considered their life history and the potential for MOs to affect their predation rates. Northern pikeminnow have a plasticity to adapt to different environs, and there are different life histories between the free-flowing and impounded river sections. Pikeminnow abundance in the lower Columbia is highest from the estuary to The Dalles, with lower abundance further upstream. Spawning occurs in June through July when temperatures are above 18°C, over clean, rocky substrate in a range of depths (Lower Columbia River Province Plan 2004 to 2005 NWPCC). In reservoir areas, high flows followed by low flows could affect recruitment. Because they spawn at multiple depths, they are less sensitive to potential dewatering. Some tributaries have viable populations that seed downstream reservoirs with juveniles, so pool fluctuations are unlikely to have population-level effects. Survival of rearing juveniles appears highest in low flow years when shoreline water temperatures are higher (20°C) and there is abundant vegetation. Northern pikeminnow are site feeders and may decrease their feeding effectiveness during higher turbidity. Northern pikeminnow would be expected to maintain their current abundance levels under the No Action Alternative.

The adult optimum temperature for walleye is 20°C to 24°C, and growth stops below 12°C. Smallmouth bass have similar spawning timeframes and temperatures (mid-May to late June, when water temperatures reach 15.6°C to 18.3°C.) Female walleye gonad maturation requires winter temperatures less than 10°C, and optimum temperatures are 6°C to 9°C. When spring temperatures increase slowly (less than 0.18 degree Celsius per day), there is poor embryo survival. As the lower Columbia River system reservoirs operate as run-of-the-river, operations are unlikely to affect these conditions. Conditions that slow fry growth (low temperatures, low zooplankton abundance, and delayed hatching), increase overwinter mortality, because smaller fish tend to have lower survival rates. Under the No Action Alternative, food abundance is supportive of walleye growth rates. The John Day Reservoir has smaller walleye, which may be an effect of harvest (no angling limits on walleye, and harvest of larger fish leaves a population of smaller individuals). Smallmouth bass juveniles are affected more by discharge than by temperature during nursery season, because fry can be displaced from nests during high flow velocity (Larimore 2000; Simonson and Swenson 1990, as cited in Brown et al. 2009.) Smallmouth bass make and tend nests until hatching, and if a nest is disturbed or depth increases beyond 4 feet, they abandon the nest; this could be affected by reservoir pool elevations.

Smallmouth bass experience a winter starvation period when temperatures are below 7°C to 10°C (Shuter et al. 1980; Henderson and Foster 1956, as cited in Brown et al. 1990) Juveniles must grow enough during their first year to survive the winter period, and juvenile shad provide an important fall forage source for growth going into winter.

Similar to Northern pikeminnow, pool elevations dropping after Walleye spawning under the No Action Alternative can strand eggs or larvae, but this is not expected to cause population-level effects. The reservoirs have generally reduced variability in seasonal and daily flows. Newly hatched fry require food (plankton) at 3 days after hatching; fry are surface oriented and need low velocities. This life stage is population-limiting below Bonneville Dam (Lower Columbia River Province Plan 2004 to 2005 NWPCC). Higher velocities during the timeframe when fry are emerging could be a method to limit production.

Smallmouth bass shift to fish prey during their first year, due to caloric intake and growth needs (Brown et al. 2009). Their diet consists of sculpin, cyprinids, suckers, and sand rollers. Juvenile salmon are eaten during their migration (at sizes of less than 100 mm).

Conditions that promote lower water temperatures and higher spring flows tend to lower the survival rates of warmwater game fish, potentially lowering populations of salmon and steelhead predators. The No Action Alternative would be expected to continue supporting warmwater game fish at levels similar to current conditions.

## MACROINVERTEBRATES

Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under the No Action Alternative. For more detailed information on the effects of the No Action Alternative on aquatic invertebrates and implications on food web interactions, see the Habitat Effects sections of these respective fish community analyses in the Resident Fish section under the applicable region.

### Region A

Aquatic invertebrate communities would continue to thrive in the aquatic environments provided by Hungry Horse Reservoir, South Fork Flathead River, Flathead River, Flathead Lake, lower Flathead River, Clark Fork River, Lake Pend Oreille, Pend Oreille River, Lake Koocanusa, and the Kootenai River.

The storage reservoirs (Hungry Horse, Lake Pend Oreille, and Lake Koocanusa) in Region A typically have low nutrients and good water quality. Reservoir elevations in the summer would continue to provide a large area for production of phytoplankton and zooplankton, with No Action Alternative operations typically filling to or nearly to full pool in most years and dropping relatively slowly through the summer. Outflows of these reservoirs would continue to carry a proportion of the zooplankton out of the reservoirs and into the rivers downstream. The varial zones of reservoirs would continue to provide habitat for production of benthic aquatic insects when inundated, and this benthic production would continue to be constrained by fluctuations in surface elevations. Larger, long-lived species would continue to dominate in the permanently wetted zones of the reservoir, and shorter-lived, smaller species would colonize the varial zone that is only inundated part of the year. These bottom-oriented aquatic insect life stages would continue to provide an important spring food source for fish. Flathead Lake and Lake Pend Oreille would also continue to support expanding populations of opossum shrimp. These shrimp would continue to compete with kokanee as both rely on zooplankton for food, but they also provide food sources for other species such as lake trout.

The riverine sections of Region A such as the Flathead River, Clark Fork River, Pend Oreille River, and Kootenai River would continue to produce benthic macroinvertebrates such as the larvae of stoneflies, caddis flies, and mayflies. The life cycle of these insects requires their habitat to stay inundated with water for 4 to 6 weeks, so their abundance and distribution would continue to be limited by fluctuations in river stage, especially in the Kootenai River where winter operations allow for varial zone desiccation, reinundation, and freezing.

**Region B**

The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic insects such as stonefly, caddisfly, and mayfly larvae. The river elevation in this reach is influenced by Lake Roosevelt operations and inflows, so it is somewhat variable, which would constrain benthic production to some degree. Under the No Action Alternative, median elevations near the U.S.-Canada border (RM 740) would fluctuate during certain times of the year. When water elevation rises in the September to January and April to June periods, water levels would allow the recolonization of benthic habitat as areas becomes inundated, but then any larvae left in the habitats as they dewater from January to April and July to August would be dried out. This likely limits the production of aquatic insects, especially the larger, longer-lived species. As the river flows downstream closer to Lake Roosevelt, the influence of reservoir operations becomes greater. The water levels would follow the same pattern as near the U.S.-Canada border, but with drops of 42 feet from January through April and 12 feet in July to August. Within Lake Roosevelt, the elevation changes modeled near Inchelium (RM 680) and further downstream near the Sanpoil River (RM 616) also followed the same pattern of filling and dewatering with similar magnitude (42 feet and 12 feet drops) as the stage at RM 720. This varial zone of the river and reservoir would likely be limited to short-lived, smaller aquatic insects that could fulfill their life cycle before being desiccated. Longer-lived species would be limited to the habitats below this annually dewatered zone. The amount of perpetually inundated habitat would increase as reservoir depth increases closer to Grand Coulee Dam.

In Lake Roosevelt, the production, distribution, and persistence of zooplankton are highly variable and sensitive to the amount of time the water is in the reservoir (retention time), which is a function of inflows, reservoir volume, and outflows. The longer water residence times allow greater abundance and larger-bodied zooplankton to be more widely distributed throughout the reservoir. Lower retention times result in fewer and smaller-bodied zooplankton that get concentrated near the dam, where they would be subject to high rates of entrainment. Zooplankton are the foundation of the food web in Lake Roosevelt, being the primary prey source for many of the key fish species at one life stage or another. Generally speaking, under the No Action Alternative, median retention time would range from about 40 to 50 days in the winter and early spring, dropping as low as 21 days by June, and then gradually increase over the summer to about 45 days at the end of August. September and October would have high retention times with a median of 60 to 80 days.

Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short retention time and low productivity. Here the macroinvertebrate community consists of production of aquatic insects similar to upstream of Lake Roosevelt, as well as the zooplankton entrained out of Lake Roosevelt. Regarding aquatic insect production and desiccation, the stage at RM 594 in Rufus Woods Lake shows about a 4-foot drop in the month of March, and a double peak in June and July. This means the elevation would increase from April to early June, peaking at a median of 966 feet, then drop sharply in June to 961 feet, then up again in early July to 964 feet and drop again to 959 feet in early September. This hydrologic regime would allow for a fairly long insect growing season with stable or rising elevation for 6 months from September through February. However, two desiccation periods in the 5-foot range, one in June and another in July and August, would likely really limit the growth and production of larval insects in the summer.

Reservoirs and river stretches below Rufus Woods Lake are run-of-the-river and so would follow similar patterns, with a double-peak in elevation changes in June and July, but the magnitude of the drop would be attenuated downstream to about a foot or less for much of this reach. These variations in stage would somewhat limit production of aquatic insects but would continue to provide habitat for production similar to current levels.

**Region C**

Benthic production in the Dworshak Reservoir is low due to the extensive variation in water surface elevation, near-shore wave action that causes erosion, and the lack of aquatic plants along the shoreline (Corps 1992 and 2015). Dworshak Reservoir pool volume typically would reach full pool on July 1, and then decline rapidly over the summer, providing a limited euphotic zone for zooplankton production.

The benthic macroinvertebrate community of the lower Snake River has been investigated on several occasions since the reservoirs were created. The most common taxa observed in the soft substrate in the Lower Snake River reservoirs were oligochaetes, amphipods (primarily corophidae), nematodes, diptera (primarily chironomids), and pelecypoda (primarily mussels).

In the hard substrate, diptera (again primarily chironomids), tricoptera (primarily caddis flies), and amphipods (both bammaridae and corophidae), according to Bennett et al. (1997) as reported by the Corps (2014). A review of mollusk diversity (Corps 2014) noted that the current mollusk fauna is dominated by the Asian clam (*Corbicula fluminea*), which became established in the Columbia River in the 1940s. The California floater (*Anodonta californiensis*), a Washington State species of concern, was also found in the sampling. The shortface lanx (*Fisherola nuttallii*) as well as three other snails (western floater [*A. kennerlyi*], knobby rams horn [*Vorticifex effuse*], and creeping ancylid [*Ferrissia rivularis*]), and the bivalve western ridged mussel (*Gonidea angulata*) were also found in small numbers. Crayfish have also been found in the reservoirs (Curet 1993; Bennett et al. 1995a; Arntzen et al. 2012). The Lower Snake River reservoirs would continue to provide production of these aquatic macroinvertebrates with a low diversity of species. Crayfish would continue to thrive in the habitats provided by rock substrate and riprap. Riverine stretches elevations would vary seasonally but generally produce similar levels of macroinvertebrates as in current conditions.

**Region D**

Very little benthic macroinvertebrate information is available for the lower Columbia River. Of those studies completed, oligochaetes, the amphipod *Corophium*, ostracods (seed shrimp), chironomids (non-biting midge larvae), nematodes, pelecypods (bivalve mollusks), hydracarina (water mites), and nemerteans (proboscis worms) were identified. Samples collected in most months also contained relatively low densities of ephemeroptera (mayflies), trichoptera (caddisflies), ceratopogonidae (biting midges), mysids (opossum shrimp), gastropods, and turbellarians. For most major taxa, densities were relatively high in the spring, declined to seasonal lows during summer, then increased to relatively high levels in the fall. Taxa present at lower densities during the summer months included nemerteans, which were frequently most abundant in autumn, pelecypods, and ostracods. *Corophium* differed most notably from this seasonal trend in that higher *Corophium* densities were observed during the summer months than during fall. The run-of-river dams would continue to be operated at stable elevations that would continue production of these aquatic macroinvertebrates.

**SUMMARY OF EFFECTS**

**Anadromous Fish**

A variety of factors affect juvenile migration and survival at the Columbia and Snake River projects. These include project structures, dam passage modifications, natural mortality, and predation. Adult migration is affected by dam passage, predation, and temperature and flow conditions. The measures in the No Action Alternative are not expected to change these factors, although temperature and flow conditions may be impacted by climate change (See Chapter 4 Climate Change).

In addition, steelhead and salmon populations in the Columbia River basin are heavily influenced by many factors unrelated to the operations and configuration of the CRS and some that occur outside of the system. These factors include competition and interbreeding with hatchery stocks; commercial, recreational, and tribal fish harvest; habitat conditions including water quality in the tributaries and migratory river corridors and yearly and decadal changes in the ocean rearing environment. Factors outside of the CRS are described throughout this document, but in general are expected to continue to influence anadromous fish in addition to the impacts associated with CRS. The trend that each species has exhibited for the past 20 years, whether upward, downward, or steady, is expected to continue under the No Action Alternative.

**Resident Fish**

Key effects are likely to continue to resident fish under the No Action Alternative. These effects include elevated summer water temperatures; elevated TDG; federal and non-federal dams that pose migration barriers, cause passage delays, or increase fish mortality; reductions in spawning and rearing habitats and changes in flow patterns and temperatures that reduce spawning and recruitment success. Elevated water temperatures would have beneficial effects to warm water resident fish and minor adverse effects to bull trout. TDG would have minor adverse effects to resident species. Non-native fish would likely continue to increase with suitable water conditions. White sturgeon would continue to successfully reproduce in some water years with adequate flow and temperature conditions, and bull trout would continue to seek thermal refugia as they migrate through the Columbia River. Reservoir operations that cause fluctuations in water elevations would continue to limit productivity and reduce access to tributary habitats in storage reservoirs, while, non-native invasive species would likely continue to increase in number and area.

**Macroinvertebrates**

Macroinvertebrate communities would continue to thrive in the aquatic environments provided by CRS project reservoirs and riverine stretches. Abundance and distribution would continue to be limited by fluctuations in reservoir elevations and river stages.

### *3.5.3.4 Multiple Objective Alternative 1*

**ANADROMOUS FISH**

**Salmon and Steelhead**

Several different ESUs of salmon and DPS of steelhead share a similar life cycle and experience similar effects from the MOs, but also have ESU or DPS specific traits that specifically drive effects differently from one another. Common effects analyses across all salmon and steelhead are discussed first, and then those ESU or DPS specific effects are displayed. Unless otherwise noted, quantitative results from COMPASS or CSS models or the Life Cycle Model (LCM) are based on a combination of hatchery and natural origin fish. This applies for both juvenile and adult results.

### *Effects Common Across Salmon and Steelhead*

<u>Summary of Key Effects</u>

MO1 includes several structural measures intended to improve juvenile migration, the block spill operations will generally increase the amount of spill at each of the lower Columbia River and lower Snake River projects for improved juvenile survival, and predator disruption operations at John Day would reduce juvenile predation by Caspian terns. During periods of increased spill, latent effects may be reduced for fish under those conditions, which could potentially increase ocean survival for those fish. Structural measures in MO1 would make small, incremental improvements in adult migration, but operational changes at Dworshak that were intended to improve thermal conditions for adult migrations in the lower Snake River actually would reduce adult migration success. Models predict that returns of salmon and steelhead would be similar or slightly higher compared to the No Action Alternative depending on species and on analytical model.

<u>Juvenile Fish Migration/Survival</u>

There are several structural measures in MO1 that may affect juvenile salmon and steelhead. Many of these structures are in one or more other MOs as well. The effects of these measures are described here and are briefly summarized where they appear in other MOs.

- *Additional Powerhouse Surface Passage* at McNary and Ice Harbor Projects.

  The percent of fish passing through turbine routes at a given project depends on flows and operations. Performance standard testing conducted at projects found the percent of fish that experienced turbine routes varied from 3 percent at the McNary Project to 12 percent at the Lower Granite Project. Because turbine routes generally have lower survival (87 to 95 percent), powerhouse surface passage routes were proposed to route additional fish to spillway or spillway like routes. For modeled species, the effects of powerhouse passage were incorporated into the COMPASS and CSS modeling directly. For COMPASS modeling, surface passage efficiencies for yearling Chinook salmon and steelhead of 40 and 50 percent respectively, were fed directly into model runs, while CSS modelers provided results with surface passage efficiencies of 10, 20, and 30 percent. From CSS modeling runs, for comparisons between MOs, a 30 percent passage efficiency was used. Even with the most optimistic 30 percent passage efficiency assumption in place, the effect of these powerhouse surface passage structures on in-river survival and subsequent adult returns was minor. These structures could potentially be more effective at influencing population level dynamics at lower spill levels than those included in MO1, but with the combination of up to 115%/120% TDG spill and performance standard spill, there were not enough fish passing via the powerhouse to have a meaningful impact.

  For those species that were not modeled, effects of powerhouse surface passage routes were described qualitatively. This would include improved juvenile survival. For dams with existing spillway surface weirs, forebay delay is insignificant under the No Action

Alternative so there is little expectation of large decreases in forebay travel times. The addition of powerhouse surface passage structures would route additional fish away from turbine passage routes to spillway or spillway-like routes where they generally have higher survival.

- Upgrade spillway weirs to ASWs at Lower Granite, Lower Monumental, Ice Harbor, McNary, and John Day Dams

The design of spillway weirs is different from existing spillways. Existing spillway gates open 50 feet below the water surface at the face of the dam and pass juvenile fish under high pressure and high velocities, while spillway weirs pass juvenile salmon and steelhead over a raised spillway crest near the water surface. Because juvenile salmon and steelhead migrate primarily in the upper 10 to 20 feet of the water column, spillway weirs are easier to find and are less stressful for fish passage. Weirs are effective in attracting about one-third of all juveniles passing the dams with survival rates over 98 percent at most projects.

ASWs are a newer generation of weir that increase the flexibility of managers to attract juvenile fish to the weir under a wider range of water flows. Effects are similar to temporary spillway weirs and removable spillway weirs. However, an ASW has a wider range of operation, flows can be increased in the spring to attract more fish and reduce flows in the summer to prolong operation. Effects of these weirs would include increased juvenile survival, reduced migration delays for juveniles, and increased operating range from high flows in spring and early summer to low flows in late summer and fall. In addition, these weirs allow for more flexibility in managing flows to improve tailrace conditions so that juvenile fish can pass quickly and avoid predation.

- *Improved Fish Passage Turbines* at John Day Project

Turbines at the John Day Project are scheduled for replacement after similar replacements have been completed at the Ice Harbor (up to three turbines) and McNary Projects (part of the No Action Alternative). As this measure will follow the Ice Harbor and McNary improvements, these improvements are currently scheduled to occur between 2025 and 2039. These new IFP turbines would have similar improvements in fish passage performance as the replacement turbines designed for install at the Ice Harbor Project. The Ice Harbor Project turbines were specifically designed for fish passage using a design process similar to what may be used for future runners at John Day Project. Turbine mortality was split into direct and indirect mortality. Direct turbine mortality includes injuries that occur during turbine passage, while indirect turbine mortality can include effects like predation that occur due to disorientation or poor egress following turbine passage. The primary sources of direct turbine mortality come from mechanical-, shear-, or pressure-related injuries.

Physical hydraulic models were used to evaluate the potential for mechanical and sheer related injuries, while potential for pressure related injuries were evaluated using sensor fish or computation fluid dynamic models. These analyses suggested that IFP turbines could reduce injury and mortality by as much as 68 percent for fixed-blade turbines and as much as 49 percent for adjustable blade turbines.

For modeling and analysis purposes, a value of 50 percent was used to evaluate reductions in injuries to juvenile salmon and steelhead that pass through turbine routes. COMPASS modeling incorporates these values directly into the model, and the results reflect the change in survival. For non-modeled species, qualitative analyses and surrogate species were used to evaluate effects of new IFP turbines. See appendix E for more information regarding these assumptions.

Several operational measures warrant discussion here individually, regarding effects to juvenile fish. Measures that would result in changes to spill, flows, passage routes, or temperatures were incorporated into the fish models. Others are not readily incorporated into modeling for effects analysis, or are modeled but may be difficult to separate from other factors, and so effects of these measures are discussed qualitatively.

- *Predator Disruption Operations*. Bird predators, including Caspian terns, ring-billed and California gulls have been shown to consume large numbers of juvenile salmon and steelhead during their downstream migration to the ocean. Blalock Islands are situated in the John Day Project pool and provide nesting habitat for colonies of Caspian terns and gulls. Under the No Action Alternative, approximately 500 breeding pairs of Caspian terns consume nearly 150,000 steelhead at these small islands annually. This measure calls for a change in operation to raise water levels in the John Day Project pool in April and May to elevations between 263.5 and 265 feet. Effects of this operation would greatly reduce potential nesting habitat for Caspian terns at the Blalock Islands. In fact, an increase in elevation of 1 foot, from 263.5 to 264.5 feet, would reduce habitat by approximately 90 percent. Recent studies show that regional efforts to dissuade Caspian tern nesting have led to a decline in Caspian tern population of approximately 44 percent (Roby 2019 presentation). Continued reductions in nesting habitat would likely be associated with continued reductions in nesting predators and increases in juvenile salmon and steelhead survival.
- *Block Spill Test (Base + 120/115%)*: A spring block spill test of alternating units of 115%/120% TDG spill (high spill block) and performance standard based spill (lower spill block). This operation would increase the proportion of spill at each of the lower Columbia River and lower Snake River projects. The high spill block would have the net effect of routing increased numbers of juvenile salmon and steelhead into spill routes and fewer through other routes, such as the juvenile fish bypasses and turbine routes. Spill levels, spill patterns, and turbine priorities also have significant effects on the survival rates of migrating juveniles via their influence on tailrace hydraulics and the formation of eddies. For juvenile salmon and steelhead, fish modeling was used when available to estimate the effects of these spill changes on fish. Increased spill could provide potential benefits to salmon and steelhead if delayed mortality is considered in relation to powerhouse encounters (see section 3.5.3.1 Comparison of CSS and COMPASS Models). The CSS predicts

that increased spill could substantially reduce latent mortality of juvenile yearling Chinook salmon moving downstream through the mainstem dams, and this outcome is reflected in the outputs of abundance in the CSS model. If this were to occur for other salmon and steelhead, SARs would also be improved. The spring block spill operation was specifically designed to test the impact of latent mortality due to passage through the CRS in a scientifically robust manner (see ISAB 2018-2).

Increasing the operating range by 6 inches at the lower Snake River Dams and at John Day Dam relative to the No Action Alternative would slightly increase juvenile fish travel times and exposure to predators. Travel time effects were included in the fish models.

The combination of all measures that affect flow patterns in the Lower Columbia River. These measures would result in changes in MO1 relative to the No Action Alternative, such as one to three percent decreases in monthly average flows March to July, a decrease of five to six percent in monthly average flow in August, and one to seven percent higher flows in December. In the lower Snake River, August flows would be 13 to 16 percent lower than the No Action Alternative, and 7 to 9 percent higher in September. Reductions in August flows were primarily driven by the measure to modify Dworshak flows to influence temperature but had the unintended and unexpected result of reducing flows while not affecting temperatures (see additional discussion in Adult Fish Migration/Survival below). Similar to the spill changes, fish modeling was used when available to estimate the effects of these flow changes on juvenile fish.

Adult Fish Migration/Survival

There are several structural measures in MO1 that may affect adult salmon and steelhead. Many of these structures are in one or more other MOs as well. The effects of these measures are described here and will be briefly summarized where they appear in other MOs.

- *Lower Granite Trap Modifications*.

  The adult fish trap at the Lower Granite Project is equipped with a weir gate that swings open in a turn pool above the trap. The gate diverts fish into the trap for data collection and trap and haul. The gate is difficult to operate and open. Consequently, the gate is rarely taken out of service and is generally closed, even when the trap is not in operation. This leads to delays in migration, occasional clogging from debris or dying shad, and blockage of downstream migrating fish. In addition, the design of the ladder creates delays in lamprey migration as they try to get over the bottom bar.

  Changing the gate to make it easier to operate would improve fish passage and reduce delays and clogging on days when the trap is not in operation. In addition, a redesign of the trap gate would allow for lamprey passage by leaving a slot in the bottom large enough for them to pass under it. These improvements would improve adult conversion and survival, reduce delays in migration, and aid in volitional downstream passage through the ladder.

- *Modify Bonneville Ladder Serpentine Weir*.

  At Bonneville Dam's Bradford Island and Washington Shore ladder flow control sections, the baffles that help slow velocities and control flows do not allow for direct line movement of fish passing the dam but requires fish to weave through the baffles. The modification of these baffles would include allowing for direct faster movement through the ladder by replacing them with ones that have in-line vertical slots and orifices.

  This measure has the potential to increase adult salmon and steelhead survival by reducing upstream travel times and higher conversion rates. A similar modification at John Day Dam, the only other CRS dam to use this type of ladder, resulted in major passage time reductions for salmon and steelhead. Similar improvements are expected for Bonneville Dam. In addition, these improvements would reduce migration delays and barriers for Pacific lamprey.

- *Lower Snake Ladder Pumps*.

  During hot summer months, warm surface water is often entrained into fish ladders at the Lower Monumental and Ice Harbor Projects, leading to a difference in temperatures between the water exiting the ladder in the tailrace and the main river within the tailrace. When these abrupt differences in temperature at ladder entrances exceed 2°C, they can lead to delays and even create barriers in fish migration as adults search for cooler passage routes.

  Installing pumps in the Lower Monumental and Ice Harbor Projects' forebays to supply water to the ladders from deeper and cooler sources would cool the ladders and reduce differences in temperature if colder water is available at deeper depths. These changes would reduce adult migration delays and barriers and would improve adult survival and conversion.

  The following measures are described in detail in the juvenile fish section above. In addition to juvenile benefits, they could have the following effects on adult migration and survival:

  - The Additional Powerhouse Surface Passage measure at McNary and Ice Harbor Projects could reduce forebay travel time and improve downstream migration of steelhead kelts.
  - Upgrading spillway weirs to AWSs at Lower Granite, Lower Monumental, Ice Harbor, McNary, and John Day Dams would reduce migration delays for steelhead kelts.
  - The Improved Fish Passage Turbines measure at the John Day Project would increase survival of salmon and steelhead that overshoot the John Day Project as well as steelhead kelts that pass back downstream through turbines.

Overall, MO1 contains structural measures at lower Columbia River and lower Snake River projects that may reduce delay for adult fish passing those projects; however, adult fallback rates may also increase under MO1 due to higher spill levels, which could increase adult fish delay (Boggs et al. 2004; Keefer et al. 2005). It is important to note that regional managers use in-season adaptive management to identify and remedy any excessive fallback.

Specific to adult salmon and steelhead passing through the lower Snake in July to September, the *Modified Dworshak Summer Draft* measure in MO1 was intended to provide cooler water during more targeted periods when the cooler water could make a difference for upstream migration conditions. However, the water quality effects analysis showed that this measure did not have the intended effect on cooling the lower Snake River corridor appreciably below 20°C during July and September in periods when water temperatures were otherwise above that threshold, and furthermore exacerbated warm water temperature issues in the August timeframe.

***Upper Columbia River Salmon and Steelhead***

Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five non-federally owned dams and reservoirs, which also influence the survival and passage of these species. The federal agencies do not dictate generation or spill levels at the PUD projects so metrics such as powerhouse encounter rate are not directly affected but are influenced by river flow levels coming through the upper Basin. The timing and volume of flow levels affected by CRS operational decisions are reflected in model analysis. COMPASS and LCM estimates of powerhouse encounter rate and SARs include passage effects from a combination of federal and PUD dam passage (Rock Island Dam to Bonneville Dam). CSS model results are not available for upper Columbia stocks.

<u>Upper Columbia Spring-Run Chinook Salmon</u>

*Summary of Key Effects*

The COMPASS modeling results support the qualitative expectations that the MO1 survival rates from McNary Dam to Bonneville Dam would increase slightly and travel times would be reduced slightly. Predator disruption operations would further increase juvenile survival. Structural improvements and reduced flows would increase adult migration success, but higher spill blocks may cause additional fallback and delay compared to the No Action Alternative. Abundance would increase by 6 percent or more if latent mortality were reduced.

*Juvenile Fish Migration/Survival*

This ESU migrates through the Columbia River downstream past the four lower CRS projects and up to five PUD owned dams. Structural and operational measures in the Common Effects section that describe changes from the No Action Alternative at McNary, John Day, The Dalles, and Bonneville Projects would apply to these fish. COMPASS modeling estimates that MO1 is expected to result in a 0.5 percent increase in average juvenile survival for upper Columbia River spring, a 5 percent decrease in average juvenile travel time from McNary Dam to Bonneville Dam, and a 6 percent decrease in the number of powerhouse passage events. Predator disruption operations, also described in Common Effects, would further increase juvenile survival by reducing predation on outmigrating smolts. TDG exposure would be the same as the No Action Alternative for these fish. CSS cohort modeling for upper Columbia River spring-run Chinook salmon was not available for this analysis.

Table 3-72 summarizes COMPASS and TDG Tool model results for upper Columbia River spring-run Chinook salmon under MO1.

**Table 3-72. Multiple Objective Alternative 1 Juvenile Model Metrics for Upper Columbia River 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 |

*Adult Fish Migration/Survival*

The *Modify Bonneville Ladder Serpentine Weir* measure, described in the Common Effects section, could decrease delay of upstream migrations, although higher spill periods of block spill could increase fallback rates. Adult exposure to TDG would be similar to the No Action Alternative.

The NWFSC LCM estimated SARS and abundance of the Wenatchee population. NWFSC LCM results predict abundance of the Wenatchee population, indicative of this ESU, could result in a slight increase of about 1 percent relative to the No Action Alternative (0.96 percent compared to 0.95 percent), assuming latent mortality was the same as in the No Action Alternative. Abundance estimates produced by the NWFSC Life Cycle model were also considered with a range of potential outcomes based on hypothetical increases in production that could be associated with reductions in latent mortality effects. While CSS modeling was not available for this population, the relationships in CSS modeling that indicate fewer powerhouse encounters would reduce latent mortality may apply to this population as well. If the 23 percent lower powerhouse encounter rate were to lower latent mortality that would subsequently increase ocean survival, abundance could increase more than 6 percent (Table 3-73).

**Table 3-73. Multiple Objective Alternative 1 Model Metrics for Adult Upper Columbia River 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%)<br>570 (10%)<br>690 (25%)<br>822 (50%) | +28 (0%)<br>+72(10%)<br>+192 (25%)<br>+324 (50%) | +6% (0%)<br>+14% (10%)<br>+39% (25%)<br>+65% (50%) |

[1] NWFSC LCM does not factor latent mortality due to the Columbia River System into the SARS or abundance output. For discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent are shown. The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if changes in the alternative were to decrease latent mortality by that much.

<u>Upper Columbia River Steelhead</u>

*Summary of Key Effects*

There are no life cycle models for upper Columbia steelhead to estimate adult returns, only COMPASS model estimates of juvenile downstream survival. Functionally, upper Columbia River steelhead juvenile migration would be about the same as the No Action Alternative. Modeled survival shows a 0.2 percent decrease, but travel time would be the same as the No Action Alternative, and powerhouse encounters would be lower. Predator disruption operations would further increase juvenile survival. Structural improvements and reduced flows could increase adult migration success. Structural measures and higher spill blocks described in the Common Effects section, including the Additional Powerhouse Surface Passage and Improved Fish Passage Turbines measures, may increase kelt survival by reducing the proportion that go through turbine routes.

*Juvenile Fish Migration/Survival*

Juveniles from this DPS migrate through the Columbia River downstream past the four lower CRS projects and up to five PUD owned dams in the mid-Columbia. Operations at upstream reservoirs that affect seasonal flow patterns downstream influence travel time and survival at the PUD owned projects. Structural and operational measures described in the Common Effects section, including the *Additional Powerhouse Surface Passage* measure at the McNary and John Day Projects, and the *Upgrade to Adjustable Spillway Weirs* measure at the McNary and John Day Projects, would decrease powerhouse passage events, as indicated in the modeling. Overall, however, COMPASS modeling estimates that MO1 is expected to result in a 0.2 percent decrease in average juvenile survival for upper Columbia steelhead, travel time would be the same as the No Action Alternative, and powerhouse passage events would decrease 5 percent. The *Predator Disruption Operations* measure, also described in Common Effects, would further increase juvenile survival by reducing predation on outmigrating smolts. TDG exposure and the resulting effect on juvenile survival would be similar to the No Action Alternative for these fish.

Table 3-74 summarizes COMPASS and TDG Tool model results for upper Columbia River steelhead under MO1. CSS cohort modeling for upper Columbia spring-run Chinook was not available for this analysis.

**Table 3-74. Multiple Objective Alternative 1 Model Metrics for Juvenile Upper Columbia 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 |

*Adult Fish Migration/Survival*

The *Modify Bonneville Ladder Serpentine Weir* measure, described in the Common Effects section, would decrease delay of upstream migrations. Structural measures designed to increase juvenile survival (*Additional Powerhouse Surface Passage at McNary and John Day*, and *Upgrade to Adjustable Spillway Weirs at McNary and John Day Projects*) would also benefit kelt survival by increasing the proportion of downstream migrating kelts going through turbine routes. Higher spill periods of block spill could increase survival of kelts by increasing non-turbine routes. Adults migrate in late summer and early fall, so 5 to 6 percent lower outflows in the lower Columbia River in August could increase upstream migration success. Adult exposure to TDG would be similar to the No Action Alternative, as the total number of days TDG would exceed the water quality standard would be lower than the No Action Alternative at McNary, John Day, and The Dalles Dams; at Bonneville Dam, there would be 1 more day than the No Action Alternative. Temperatures would also be very similar to No Action Alternative. The number of days exceeding state temperature standards at the four lower river projects would be less than 1 percent higher than the No Action Alternative.

<u>Upper Columbia River Coho Salmon</u>

See upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile upper Columbia coho salmon and upper Columbia fall Chinook salmon analysis as a surrogate for adult upper Columbia coho salmon.

*Summary of Key Effects*

The primary challenges for upper Columbia River coho salmon are the conditions they encounter during upstream and downstream migrations. Downstream survival and migration for juveniles is dependent on water flow and routing at the dams. Higher flows and higher spills generally lead to higher survival. Juvenile coho survival would be similar to upper Columbia River spring-run Chinook salmon, with structural measures and spill increases potentially increasing juvenile survival and additional increases in survival due to lower avian predation in the John Day area. Adult coho salmon migration timing is similar to upper Columbia River fall Chinook salmon so that species is used as a surrogate for upstream migration effects.

*Juvenile Fish Migration/Survival*

See upper Columbia River spring-run Chinook salmon results as a surrogate for juvenile upper Columbia River coho salmon.

*Adult Fish Migration/Survival*

Adult migration conditions would be similar to upper Columbia Fall Chinook, which were analyzed in a workshop using water quality and hydrology information. MO1 water quality modeling showed no change in the frequency of water temperatures exceeding 20°C relative to the No Action Alternative, but a higher incidence of adult ladder temperature differentials above 2°C, which could delay upstream migration. Upper Columbia coho salmon migrate upstream as adults in August/September (early run) and October/November (late run), so migration success of a portion of the early run may be affected with 5 to 6 percent lower flows in August. See upper Columbia Fall Chinook salmon results as a surrogate for adult upper Columbia coho salmon.

<u>Upper Columbia River Sockeye Salmon</u>

Refer to the upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia River sockeye salmon.

*Summary of Key Effects*

MO1 would result in similar or minor improvements in juvenile migration over the No Action Alternative. Survival would be similar to upper Columbia River spring-run Chinook salmon, with structural measures and spill increases resulting in potentially minor increases in juvenile survival, and additional increases in survival due to lower predation by birds in the John Day area. Adult migration would be similar to the No Action Alternative.

*Juvenile Fish Migration/Survival*

Juvenile survival of upper Columbia River sockeye salmon is estimated using COMPASS juvenile modeling results for upper Columbia River spring-run Chinook salmon as a surrogate.

MO1 would have negligible increases in survival rates for juvenile sockeye passing downstream through the lower Columbia River compared to the No Action Alternative; travel time and powerhouse encounters would exhibit minor decreases. Structural measures, such as the *Additional Powerhouse Surface Passage* measure at the McNary and John Day Projects and the *Upgrade to Adjustable Spillway Weirs* measure at the McNary and John Day Projects, as well as the *Predator Disruption Operations* measure described in Common Effects would increase survival by increasing proportions of fish to pass through the spillways. This is in addition to increased survival of sockeye juveniles passing through John Day Dam turbines.

Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia River sockeye salmon, for additional information in modeled juvenile fish migration and survival metrics.

*Adult Fish Migration/Survival*

The summer water temperatures in the river during the upstream migration would be similar to the No Action Alternative, with thermal issues continuing to reduce adult survival in warm years, and TDG exposure would be similar to the No Action Alternative. Structural improvement of the *Modify Bonneville Ladder Serpentine Weir*, described in Common Effects at the Bonneville Project, could reduce migration delay.

Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia River sockeye salmon, for additional information in modeled adult fish migration and survival metrics.

<u>Upper Columbia River Summer/Fall-Run Chinook Salmon</u>

*Summary of Key Effects*

Juvenile upper Columbia summer/fall-run Chinook salmon would be similar to the No Action Alternative, with potential increases in juvenile survival due to lower predation in the John Day Dam pool. There may be slightly greater adult migration delay due to higher incidence of adult ladder temperature differentials above 2°C.

*Larval Development/Juvenile Rearing in Mainstem Habitats*

None of the measures of MO1 would change the substrate sizes or distribution in the spawning areas or expand suitable spawning areas; therefore, this alternative is expected to have the same larval development and juvenile rearing habitat conditions as the No Action Alternative. The same is true for river depths in the spawning areas; no change is anticipated for eggs incubating in the gravel. Once juvenile Chinook salmon have emerged and moved to the reservoirs for rearing, lack of summer cooling water may reduce quality of rearing habitat for fish that holdover for their first year; however, the changes for MO1 would not be a measurable difference compared to the No Action Alternative. No change is anticipated in McNary and John Day Dam reservoir plankton communities or shoreline habitats under MO1, relative to the No Action Alternative. Likewise, juvenile rearing habitat below Bonneville Dam is not expected to change relative to the No Action Alternative.

*Juvenile Fish Migration/Survival*

Juvenile summer/fall-run Chinook salmon are especially susceptible to predation in the Columbia River from the Okanogan River to downstream of McNary Dam. Water temperatures would be the same as the No Action Alternative and would not change predation rates in this reach. Downstream migration of juveniles would be similar to the No Action Alternative as well.

*Adult Fish Migration/Survival*

The number of days water temperatures in the McNary Dam tailrace exceed 20°C would not change relative to the No Action Alternative, so no change in migration delay, fallback, or susceptibility to disease are anticipated due to overall warmer mainstem water temperatures at the lower Columbia River Dams. However, the number of days that adult ladder water temperatures were greater than 2°C in difference would increase from 2.8 percent of days (No Action Alternative) to 4.2 percent of days (MO1), which may slightly increase the delay in dam passage for adult fish (Caudill et al. 2013).

Specific to Okanogan upper Columbia River summer/fall-run Chinook salmon, there would be no change in the number of days the mainstem would be 20°C or higher at the confluence of the Okanogan River, relative to the No Action Alternative. This means that there would be no change anticipated in the ability of the Okanogan fish to wait (hold) in the mainstem until water temperatures in the Okanogan River are cool enough for adults to move up from the mainstem without having to migrate through water temperatures typically considered lethal for salmon and steelhead (Ashbrook et al. 2009).

The frequency of meeting the Vernita Bar Agreement to protect fall-run Chinook salmon spawning in and around the Hanford Reach of the Columbia River in Washington is not expected to change under any MOs relative to the No Action Alternative. Other operational changes under the MOs are likewise not anticipated to affect upper Columbia River summer/fall-run Chinook salmon spawning from the tailrace of Chief Joseph Dam to Bonneville Dam in terms of changes in flows, water temperatures, or TDG generated under the MOs.

***Middle Columbia River Salmon and Steelhead***

<u>Middle Columbia River Spring-Run Chinook Salmon</u>

See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River Spring-Run Chinook Salmon.

*Summary of Key Effects*

Changes in effects to middle Columbia River spring-run Chinook salmon juvenile and adult migrations and adult returns under MO1 would be similar to the No Action Alternative.

*Juvenile Fish Migration/Survival*

See upper Columbia River spring-run Chinook analysis as a surrogate for juvenile middle Columbia River spring-run Chinook salmon. Middle Columbia River juvenile salmon would typically experience higher absolute survival than upper Columbia River spring-run Chinook salmon because they do not travel as far through the Columbia River System and through up to five non-federal owned dams. However, the surrogate metric used for upper Columbia River spring-run Chinook salmon is survival from McNary to Bonneville Dam and would be similar for middle Columbia spring-run Chinook salmon that pass the same CRS projects.

*Adult Fish Migration/Survival*

Effects to middle Columbia River spring-run Chinook salmon adults would be similar to upper Columbia River spring-run Chinook salmon. Structural improvements and reduced flows would increase adult migration success, but higher spill blocks may cause additional fallback and delay compared to the No Action Alternative. See upper Columbia River spring-run Chinook analysis for surrogate information on adult middle Columbia River spring-run Chinook salmon under MO1 and comparisons to No Action Alternative.

<u>Middle Columbia River Steelhead</u>

*Summary of Key Effects*

Changes in effects to middle Columbia River steelhead juvenile and adult migration and returns under MO1 would be similar to the No Action Alternative. Certain structural measures, including the *Additional Powerhouse Surface Passage* and *Improved Fish Passage Turbines* measures, and higher spill levels under the *Block Spill Test (Base +120/115%)* measure would result in higher survival rates for adult steelhead falling back through the dams and kelts migrating downstream.

*Juvenile Fish Migration/Survival*

Populations of mid-Columbia River steelhead distributed between the Deschutes and Walla Walla Rivers pass two to four CRS dams in the lower Columbia on their downstream migration to the ocean. Modeling was not available for middle Columbia River steelhead, so juvenile survival of upper Columbia steelhead was used as a surrogate of juvenile survival through the Bonneville project (pool and dam) for this portion of the DPS. COMPASS modeling predicted a negligible decrease in survival and slower travel times under MO1, compared to the No Action Alternative. TDG would also be similar to the No Action Alternative. Refer to Upper Columbia River steelhead analysis (Section 3.5.3.3) for surrogate information on Middle Columbia River steelhead.

Predator disruption operations, as described in the Common Effects section, would reduce predation on outmigrating middle Columbia River steelhead smolts and increase juvenile survival. Functionally, reduced predation rates by Caspian terns between McNary and John Day dams that would result in increased juvenile survival, combined with reduced survival between McNary and Bonneville dams would likely result in similar survival of middle Columbia River steelhead in MO1 compared to the No Action Alternative.

*Adult Fish Migration/Survival*

Structural measures such as *Modify Bonneville Ladder Serpentine Weir* are expected to reduce delay associated with upstream passage. Higher spill levels during April periods under the *Block Spill Test (Base + 120/115%)* measure would result in higher survival rates for adult steelhead falling back through dams and kelts migrating downstream, as fewer adults would use powerhouse passage routes with increased availability of spill routes. Downstream passage survival would also increase when surface passage was available (Normandeau et al. 2014; Richins and Skalski 2018).

***Snake River Salmon and Steelhead***

Snake River Spring/Summer-Run Chinook Salmon

*Summary of Key Effects*

Modeling and qualitative analyses indicate that MO1 would result in similar or slightly higher overall returns of Snake River spring/summer-run Chinook salmon. Juvenile survival would be very similar to the No Action Alternative (about 0.5 percent higher). Certain structural measures would provide benefits to adults migrating upstream. Overall abundance of returning adults may increase between 0 and 40 percent based on population and latent mortality assumptions.

*Juvenile Fish Migration/Survival*

This ESU migrates through the Snake and Columbia Rivers downstream past the eight CRS projects: four on the Snake River and four on the lower Columbia River. Structural and operational measures the Common Effects section that describe changes at all of these dams would affect these fish. The combination of several measures would, similar to the No Action Alternative, would be expected to decrease travel time and powerhouse encounters and overall increase juvenile outmigration survival, such as the *Additional Powerhouse Surface Passage*, *Upgrade to Adjustable Spillway Weirs,* and *Improved Fish Passage Turbines* measures. For Snake River spring/summer-run Chinook salmon, the COMPASS and CSS cohort models estimate that MO1 would increase juvenile survival from Lower Granite Dam to Bonneville Dam by less than 1 percent, and travel time would decrease less than 2 percent. The structural measures and increase in spill during block periods would be expected to decrease powerhouse encounters somewhat, with the models predicting a relative decrease of about 16 to 19 percent. The *Predator Disruption Operations* measure, also described in Common Effects, would further increase juvenile survival by reducing predation on outmigrating smolts. TDG exposure would be less than 1 percent higher than the No Action Alternative, with a reach average exposure of 115.1 percent TDG. See Table 3-75 for a list of model outputs related to juvenile migration and survival.

**Table 3-75. Multiple Objective Alternative 1 Juvenile Model Metrics for Snake River 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 |

Several measures in MO1 would affect juvenile Snake River spring/summer-run Chinook salmon transportation rates. The NWFSC LCM predicted a negligible decrease in the overall proportion of fish transported compared to the No Action Alternative, at about 38 percent of juveniles transported. CSS, however, predicted an increase of 7.3 percent in transportation rate compared to the CSS-modeled No Action Alternative. The CSS also predicted a lower total transport rate with an absolute value of 26.5 percent of smolts transported under MO1, as well as a decrease in the benefit to survival for transported smolts. The difference in modeled transportation rates is likely due to the fact that the COMPASS model only uses natural origin juveniles to assess transport rates while CSS includes hatchery fish as well.

Smolts would be collected for transportation at the three Snake River collector projects starting on April 15 under the *Early Start Transport* measure of MO1, which is earlier than the No Action Alternative start date of April 25. The intent of this measure was to increase the region's understanding of early season transport effects and to benefit early migrating Snake River steelhead. With regard to Snake River spring/summer Chinook, the earlier start to juvenile fish transport would have a neutral effect on the TIR, though hatchery origin Chinook salmon smolts have a greater benefit of transportation during this timeframe than natural origin smolts (Transport COP; Gosselin et al. 2018). However, because of the lower conversion rates associated with fish that were transported as juveniles (Keefer et al. 2008; FPC memo 13-19), without a clear benefit for the early period, earlier transport may slightly decrease Snake River spring/summer-run Chinook salmon adult returns to spawning grounds.

The increased spill in the high spill blocks associated with the *Block Spill Test (Base + 120/115%)* measure, would also increase the number of juveniles passing via spillways and thus not able to be collected in the juvenile fish bypasses for transportation. Reducing transport rates, especially in May and June, would be expected to reduce SARs because those transported fish typically have higher SARs than those of in-river migrants during this period.

Across the entire spring migration season in both the No Action Alternative and MO1, the CSS cohort model predicted lower return rates for juvenile Snake River Chinook that were transported compared to fish that migrated in-river as juveniles. The benefit of transport in MO1 was even less than the No Action Alternative and this difference is likely the result of higher in-river SARs predicted by the CSS model under MO1.

*Adult Fish Migration/Survival*

Several structural measures in MO1 are anticipated to benefit adult Snake River spring/summer-run Chinook salmon passage upstream, including *Lower Granite Trap Modifications, Modify Bonneville Serpentine Weir* (reducing delay), and *Lower Snake Ladder Pumps* if there is cooler water available at depth. However, MO1 has block periods of higher spill under the *Block Spill Test (base + 120/115%)* measure, and fallback rates of Snake River spring/summer-run Chinook salmon may increase because fallback for this ESU has been associated with higher flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). In recent years, adult passage delays have been observed at Little Goose Dam with spill levels over 30-35 percent. It is important to note that regional managers use in-season management techniques to identify and remedy any excessive fallback, which would likely mitigate for this increase in spill. Potential spill reduction starting during as early as August 1 using a spill trigger may reduce fallback for the few summer migrating adults that may still be migrating in August and no effects on spring migrating adults. However, while fallback rates may be lower, individuals that fell back would experience greater risk of falling back through turbines and juvenile bypass systems compared to spillways once the spill cessation trigger is met at individual lower Snake River projects.

Increasing the reservoir operating range by 6 inches at the lower Snake River Dams (MOP 1.5-foot range) and at John Day Dam (MIP 2-foot range) would have little effect on flow, and thus is not expected to affect adult migration timing or survival rates (NMFS 2019). Similarly, holding contingency reserves within juvenile fish passage spill is likely to have little effect, if any, on adult migration.

Finally, the modified Dworshak releases in MO1 were intended to provide cooler water during more targeted periods when the cooler water could make a difference for upstream migration conditions. However, the water quality effects analysis showed that this measure did not have the intended effect on cooling the lower Snake River corridor appreciably below 20°C during July and September in periods when water temperatures were otherwise above that threshold, and furthermore exacerbated warmwater temperatures in the August timeframe. This measure is unlikely to affect the few Snake River spring/summer-run Chinook salmon still migrating in the latter half of July.

Table 3-76 displays the median model outputs for adult metrics from both NWFSC LCM and CSS. NWFSC LCM results include different scenarios of latent mortality in the ocean survival phase, including decreased mortality of 0 percent, 10 percent, 25 percent, and 50 percent (scenario indicated in parentheses).

**Table 3-76. Multiple Objective Alternative 1 Adult Model Metrics for Snake River 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%)<br>0.93% (10%)<br>1.00% (25%)<br>1.12% (50%) | 0 (0%)<br>+0.05% (10%)<br>+0.12% (25%)<br>0.24% (50%) | 0% (0%)<br>+6% (10%)<br>+14% (25%)<br>+28% (50%) |
| SARs LGR-BON (CSS) | 2.0% | 2.2% | +0.2% | +10% |

| 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%)<br>2,563 (10%)<br>2,826 (25%)<br>3,290 (50%) | +60 (0%)<br>+212 (10%)<br>+475 (25%)<br>+939 (50%) | +3% (0%)<br>+9% (10%)<br>+20% (25%)<br>+40% (50%) |
| Abundance of Grande Ronde/Imnaha representative populations (CSS)[3/] | 6,114 | 6,428 | +314 | +5% |

1/ NWFSC LCM does not factor latent mortality due to the Columbia River System into the SARS or abundance outputs. For discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent are shown. The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent scenarios of what SARs or abundance hypothetically could be under the increased ocean survival scenario if changes in the alternative were to decrease latent mortality by that much.

2/ NWFSC LCM provided results for 16 populations in the upper Salmon River, South Fork Salmon River, and Middle Fork Salmon River major population groups. The absolute values include these populations only, the percent change is considered indicative of the Snake River ESU of spring-run Chinook salmon for the purpose of comparing between MOs.

3/ CSS provided results for six populations in the Grande Ronde/Imnaha major population group. The absolute values represent those populations only; the percent change is considered indicative of the Snake River ESU of spring-run Chinook salmon for the purpose of comparing between MOs.

The NWFSC LCM estimates SARs and abundance of the upper Salmon River, South Fork Salmon River, and Middle Fork Salmon River MPGs. CSS estimates the abundance of Grande Ronde/Imnaha MPG. Both models use a combination of hatchery and natural origin fish. For comparison purposes, the percent change from the No Action Alternative is considered indicative of the effects of MO1 on the Snake River spring-run Chinook salmon ESU.

The NWFSC LCM predicts MO1 would result in a range from no change to a 28 percent relative increase in the smolt to return as adult rates to Bonneville Dam depending on the magnitude of latent mortality assumptions applied. The CSS model predicts a change of 0.2 percent increase (10 percent relative change) in survival of smolts from Lower Granite Dam to return as adults back to Bonneville Dam (from 2.0 percent in the No Action Alternative to 2.2 percent under MO1).

With slight increases in juvenile survival both in the freshwater migration and in the ocean to adulthood, increases in abundance of fish to the spawning grounds would be expected. The NWFSC model, looking at the Middle Fork Salmon and South Fork Salmon MPGs, showed an average overall increase of about 3 percent without factoring in any change to latent mortality. The abundance change in individual populations would range from a 1 percent decrease (Big Creek population) to a 4 percent increase (Bear Valley Creek population). Smolts would experience fewer powerhouse routes, on average, that could potentially reduce latent mortality somewhat from the No Action Alternative and that could increase the adult returns more than indicated by the model. The CSS models, using the Grande Ronde/Imnaha MPG, indicated about 5 percent increase in abundance, with a range of from 5 percent to 12 percent increase in individual populations. With consideration of confidence of the models, this would indicate likely similar abundance.

Qualitatively, MO1 would provide contrasting spill levels to test latent mortality effects under the *Block Spill Test (base + 120/115%)* measure, but would not likely change the overall expected latent mortality much because travel time, powerhouse encounters, and TDG exposure are similar to the No Action Alternative. The CSS models indicate ocean survival would be similar to the No Action Alternative. The NWFSC LCM SARS and abundance results with 0 to 10 percent decreased latent mortality assumptions are similar to CSS results.

<u>Snake River Steelhead</u>

*Summary of Key Effects*

Juvenile survival would be similar to the No Action Alternative, with models showing similar travel time and TDG exposure and lower powerhouse encounters, and predation may be decreased with the predator disruption measure. Structural measures and blocks of higher spill may increase kelt survival but warmer water temperatures in the Snake River would decrease it. The warmer August temperatures driven by operational changes at Dworshak would also reduce upstream migration survival and success. CSS modeled SARs predicted that returning adults to Bonneville may increase by up to 5 percent.

*Juvenile Fish Migration/Survival*

This DPS migrates through the Snake and Columbia Rivers downstream past the eight CRS projects, four on the Snake River, and four on the lower Columbia River. Structural and operational measures described in the Common Effects section that describe changes at these projects would apply to these fish. The combination of several measures would maintain overall travel time, reduce powerhouse encounters, and increase survival including the *Additional Powerhouse Surface Passage* measure at the McNary and John Day Projects, and the *Upgrade to Adjustable Spillway Weirs* measure at the McNary and John Day Projects. For Snake River steelhead, the COMPASS model predicts a decrease in juvenile survival of 0.5 percent, and CSS cohort models estimate that MO1 would increase juvenile survival from Lower Granite Dam to Bonneville Dam by 1.7 percent. Both models agree that travel time would be nearly the same and that powerhouse encounters would decrease 15 to 16 percent. The *Predator Disruption Operations* measure, also described in Common Effects, would further increase juvenile survival by reducing predation on outmigrating steelhead smolts. TDG exposure would be less than 1 percent higher under the *Block Spill Test (Base +120/115%)* measure of MO1 than the No Action Alternative, with a reach average exposure of 115.1 percent TDG and little effect on juvenile survival. See Table 3-77 for a list of model outputs related to juvenile migration and survival.

**Table 3-77. Juvenile Model Metrics for Snake River Steelhead under Multiple Objective 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 |

Several measures in MO1, such as *Early Start Transport* affect juvenile Snake River steelhead transportation rates, and season-wide, the CSS cohort model estimates a reduction in TIR (i.e., reduction in transport benefit, relative to migration in-river) of about 23 percent compared to the TIR under the No Action Alternative. While a MO1 TIR of 1.08 represents a reduction in TIR relative to the No Action Alternative (TIR 1.41), the TIR still represents a season-wide benefit to steelhead that are transported relative to in-river migration, measured in terms of relative SARs (DeHart CRSO-24/2019).

The *Early Start Transport* measure would affect the change in transportation including an earlier start to transport date (April 15) relative to the No Action Alternative start to transport date of April 25. The earlier start to juvenile fish transport would likely increase adult returns for hatchery origin steelhead and would have a neutral effect on natural origin steelhead. Thus, the earlier transport date is likely not a driver of the TIR response relative to the No Action Alternative because the effect should be beneficial or neutral, not adverse.

The *Block Spill Test (Base + 120/115%)* measure would increase the number of juveniles passing via spillways and thus would be unable to be collected in juvenile fish bypasses for transportation. Reducing transport rates, especially in May and June, would be expected to decrease total adult returns of steelhead. Higher MO1 in-river survival compared to the No Action Alternative may also be a factor in the lower season-wide TIR in MO1 and is most likely driver of the change in MO1 relative to the No Action Alternative. Overall, across the entire spring migration season, the CSS cohort model estimated in-river migrants would return at a lower rate than transported migrants under MO1 because the TIR was greater than 1 (average TIR 1.08). This relative return rate of transported fish was less than the return rate of transported fish for the No Action Alternative (TIR 1.41). However, TIR varies throughout the season and so this overall TIR estimate does not provide information on the specific dates within the season when transporting fish may yield higher or lower returns than the season wide average.

The COMPASS and CSS cohort model results support the qualitative expectations that the MO1 survival rates from the lower Snake River to below Bonneville Dam would be similar to the No Action Alternative.

*Adult Fish Migration/Survival*

Several structural measures in MO1 are anticipated to benefit adult steelhead passage upstream, including *Lower Granite Trap Modifications* and *Modify Bonneville Ladder Serpentine Weir* (reducing delay), *Lower Snake Ladder Pumps*, if cooler water is present at depth in the forebays. Structural measures designed to increase juvenile survival (*Additional Powerhouse Surface Passage* and *Upgrade to Adjustable Spillway Weirs*) could also benefit kelt survival by increasing the proportion of downstream migrating kelts going through non-turbine routes. Higher spill periods of block spill could increase survival of kelts by increasing non-turbine routes. Warmer Snake River temperatures in August due to modified operations at Dworshak Dam would decrease steelhead upstream migration survival and success. Adult exposure to TDG would be similar to the No Action Alternative.

Higher spill levels during April periods should result in higher survival rates for adult steelhead falling back through dams and kelts migrating downstream, as fewer adults used powerhouse passage routes when a spill route was available and overall downstream passage increased when surface passage was available (Normandeau et al. 2014).

For Snake River steelhead, the CSS cohort model estimates that SARs would increase 5 percent from the No Action Alternative. Table 3-78 displays the CSS cohort model results for Snake River steelhead. NWFSC LCM modeling for Snake River steelhead was not available.

**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% |

Under MO1, fewer steelhead would be transported because of higher spill levels under the *Block Spill Test (Base + 120/115%)* measure. Based on observed data, without considering latent mortality, this is anticipated to result in a negligible change to return rates at Lower Granite Dam.

<u>Snake River Coho Salmon</u>

See Snake River spring/summer-run Chinook as a surrogate for juvenile Snake River coho salmon and Snake River fall-run Chinook as a qualitative surrogate for adult Snake River coho salmon.

*Summary of Key Effects*

Surrogate species modeling predicts a minor increase in survival in juvenile Snake River coho salmon. However, a survival increase for Snake River juvenile coho may be offset by an increase in water temperatures above 20°C that may be experienced by adult Snake River coho migrating through the lower Snake reach. This increase may increase delay, fallback, and susceptibility to disease by adults under MO1, compared to the No Action Alternative.

*Juvenile Fish Migration/Survival*

Based on Snake River surrogate species under MO1, juvenile survival of coho salmon would have minor increases in survival, minor reductions in travel times, and major reductions in powerhouse encounters, compared to the No Action Alternative. Refer to Snake River spring/summer-run Chinook as a surrogate for juvenile Snake River coho salmon for additional information.

*Adult Fish Migration/Survival*

For the lower Snake River reach, MO1 water quality modeling showed an increase in the frequency of water temperatures exceeding 20°C relative to the No Action Alternative. Adult Snake River coho salmon could experience a greater delay in their adult migration, increase in fallbacks at lower Snake River dams, and increase in susceptibility to disease compared to the No Action Alternative. Ultimately, increased (warmer) water temperatures would pose a greater risk to adult survival. This mechanism is described in more detail for *Snake* River fall-run Chinook (Section 3.5.3.3) as a surrogate for adult Snake River coho salmon.

Snake River Sockeye Salmon

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake River sockeye salmon.

*Summary of Key Effects*

Juvenile migration and survival would be similar or slightly better than the No Action Alternative with lower powerhouse encounter rates but similar travel time and TDG exposure. For adults, the most notable effect of MO1 is the increased risk of delay in upstream migration due to warmer river temperatures and increased temperature differential at the fish ladders.

*Juvenile Fish Migration/Survival*

This alternative is expected to result in a slightly faster migration time for juvenile Snake River sockeye salmon based on modeling results for juvenile Snake River Chinook salmon. Refer to the analysis of Snake River spring/summer-run Chinook salmon as a surrogate for Snake River sockeye salmon in Section 3.5.3.2. Juvenile sockeye salmon migrate faster than yearling Chinook, and it is assumed that slightly faster travel times would result in better survival due to less swimming effort and shorter duration of exposure to predators; the overall result is better survival rates. Along with the slightly faster travel time, modeled surrogate analyses predict that juvenile fish would also experience fewer powerhouse encounters relative to the No Action Alternative from MO1's *Additional Powerhouse Surface Passage*, *Upgrade to Adjustable Spillway Weirs,* and *Improved Fish Passage Turbines* measures, which may result in increased survival to adult returns.

Increased block spill rates under MO1's *Block Spill Test (Base + 120/115%)* measure may contribute to the faster travel time, but the change in travel time due to spill rate is not a substantial difference. The mean water temperature during juvenile outmigration is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish. Under the *Predator Disruption Operations* measure, the proposed operations at John Day Dam to increase the reservoir operating range could reduce nesting habitat for birds that eat salmon on the Blalock Islands, which would reduce mortality of juvenile sockeye salmon.

Transportation of sockeye salmon could change due to spill and transportation measures in MO1, including the *Block Spill Test (Base + 120/115%)* and *Early Start Transport* measures. The outmigration window is more compressed, with the bulk of the smolts passing April through the end of May. However, starting transport earlier in April could increase transportation of juvenile sockeye salmon depending on the annual run-timing of downstream migrants.

*Adult Fish Migration/Survival*

Transport for sockeye as juveniles results in more fallback and longer migration time as adults, and more straying during upstream migration. Sockeye transported in the Snake River are more likely to fall back than in-river migrating fish (Crozier et al. 2015). Transportation of juveniles appears to impair adult homing ability (i.e., ability to return to their birth streams), which results in migration delay, increased fallback, and straying. This impaired homing ability may contribute to higher incidental harvest rates in the lower Columbia River than middle Columbia sockeye salmon, which are the targets of the fishery. This impaired homing ability can be lethal during warm water years such as 2015. MO1 may decrease transport, as described in the juvenile section, which could increase adult survival and migration success.

The summer water temperatures in the river during the last week of sockeye migration would reduce migration success and survival of those fish; this represents a small portion of the run. The temperature differential between the river and the fish ladders would change under MO1. This alternative is estimated to have 65.5 percent of all days during the upstream migration period with a greater than 2 degree Celsius temperature difference between the river and the fish ladders compared to 50 percent of all days in the No Action Alternative. Experiencing substantially more days with a greater than 2 degree Celsius temperature differential between river water and the fish ladders would cause a greater risk of delay at the dams. Management of fish ladder temperatures has already been implemented at Little Goose and Lower Granite Dams, which were both identified as the top priority locations. Addition of ladder temperature management at Ice Harbor and lower Monumental Dams is part of MO1's *Lower Snake Ladder Pumps* measure.

Important water quality parameters, such as TDG and its effects in the form of GBT would have no appreciable difference in MO1 from the No Action Alternative for either adults or juveniles. Likewise, there would be no change to sediment concentrations or DO levels from any measures in MO1.

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for additional information on adult Snake River sockeye salmon in Section 3.5.3.2.

<u>Snake River Fall-Run Chinook Salmon</u>

*Summary of Key Effects*

The most notable effect of MO1 is the increased risk of delay of adults migrating upstream at the fish ladders in late August due to water temperature differentials in the ladders.

*Larval Development/Juvenile Rearing*

None of the measures of MO1 would change the substrate sizes or distribution in the spawning areas or expand suitable spawning areas; therefore, this alternative is expected to have the same larval development and juvenile rearing habitat conditions as the No Action Alternative. The same is true for river depths in the spawning areas; no change is anticipated for eggs incubating in the gravel. Once juvenile Chinook salmon have emerged and moved to the reservoirs for rearing, lack of summer cooling water may reduce quality of rearing habitat for fish that hold over for their first year; however, the changes for MO1 would not be a measurable difference compared to the No Action Alternative.

*Juvenile Fish Migration/Survival*

In-river survival would be expected to be similar to the No Action Alternative because summer spill levels are the same. If spill levels were curtailed in August under this MO, the number of fish actively migrating through the Snake River are small enough that while there may be impacts to individual fish, there would not be a population level response expected. Transportation typically benefits Snake River juvenile fall Chinook in August, so any decreases in dam passage survival would likely be offset by increased returns from smolts that were transported downstream. Under MO1, there would be a slight reduction in risk of predation in May through July due to slightly reduced mean temperatures compared to the No Action Alternative. The mean temperature is expected to be 16.4°C, with 25.2 percent of days over 20°C, which is a slight improvement from the No Action Alternative. Additionally, bird predation risk would decrease slightly due to changing operations at John Day Dam to reduce availability of bird nesting habitat under the *Predator Disruption Operations* measure. Effects would be more noticeable for species like spring Chinook salmon and steelhead that migrate earlier, but would still be effective for Snake River fall-run Chinook salmon. None of the measures in MO1 would affect turbidity during the juvenile outmigration months of May through July; therefore, their visual cover from predation would not change.

*Adult Fish Migration/Survival*

Transport as juveniles results in more fallback and longer migration time as adults and more straying during upstream migration. Fish transported in the Snake River are more likely to fall back than in river fish (Bond et al. 2017). Under MO1, the portion of juveniles transported downstream would be approximately 38 percent compared to 39 percent in the No Action Alternative; therefore, the rate of fallback and straying by adult upstream migrants would likely remain the same.

MO1 has a higher risk of delay and fallback because of changes to cooling water augmentation from Dworshak Dam under the *Modified Dworshak Summer Draft* measure. Temperatures at McNary Dam would have a slight increase, and temperatures at Ice Harbor Dam would have a pronounced increase with 62.7 percent of all days over 20°C compared to 54.3 percent in the No Action Alternative. Water temperatures delay adult migration during summer/fall when they exceed ~20°C. Increased adult straying is correlated with elevated temperatures. Warm water temperatures can also increase susceptibility to disease. All of these effects reduce survival and spawning success, including gamete viability.

This alternative is estimated to have 65.5 percent of all days in August and September with a greater than 2 degree Celsius temperature difference between the river and the fish ladders compared to 50 percent of all days in the No Action Alternative; this is an additional 9 days during the migration period. The impact would be most noticeable during low-water/high-temperature years when there is less water available for cooling. Management of fish ladder temperatures has already been implemented at Little Goose and Lower Granite Dams, which were both identified as the top priority locations. Addition of ladder temperature management at Ice Harbor and lower Monumental Dams is part of MO1's *Lower Snake Ladder Pumps* measure.

There would be no change to sediment concentrations or DO levels from the No Action Alternative as a result of any measures in MO1 during the adult migration period.

***Lower Columbia River Salmon and Steelhead***

<u>Lower Columbia River Chinook Salmon</u>

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower Columbia River Chinook salmon.

*Summary of Key Effects*

Juvenile survival and travel time would be similar to the No Action Alternative, with the possible exception that the fall run of Lower Columbia River Chinook salmon, which could experience slightly slower outmigration due to 4 to 5 percent lower flows in late summer. Adult migration and survival would be similar to the No Action Alternative, with potentially higher fallback during the higher spill block periods for the spring-run fish.

The results (and change from the No Action Alternative) for metrics for lower Columbia River Chinook salmon follow:

- Negligible increase in juvenile project survival at Bonneville Reservoir and Dam (see surrogate Snake River spring-run/summer-run Chinook salmon) = (+0.1 percent)
- Bonneville Dam outflows, April to June = (-1 percent to -2 percent)
- Bonneville Dam outflows, August to September = (-4 percent to -5 percent)

- Spill, Bonneville Dam = April (+3 percent), May (+1 percent), August (-1 percent)
- Temperature, The Dalles Dam, days exceeding state standard = 72 days (+1 day)
- Temperature, Bonneville Dam, days exceeding state standard = 57 days (-1 day)
- TDG, The Dalles Dam, days exceeding state standard = 29 days (+4 days)
- TDG, Bonneville Dam, days exceeding state standard = 64 days (+3 days)

*Juvenile Fish Migration/Survival*

Five of the 32 populations of Lower Columbia River Chinook salmon pass Bonneville Dam on their downstream outmigration to the ocean. Modeling was not available for this ESU, so juvenile survival of Snake River spring-run/summer-run Chinook salmon at Bonneville Dam was used as a surrogate of juvenile survival. COMPASS modeling predicts juvenile survival to be similar in MO1 to the No Action Alternative. Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for additional information relevant to lower Columbia River Chinook salmon.

Outflows can influence juvenile outmigration if changes in flows are enough to affect travel time and therefore survival. Hydrology modeling predicts spring-run and late-fall-run fish would experience outflows about one to two percent lower than the No Action Alternative. Fall-run fish outmigrate in late summer and may see flows up to 4 or 5 percent lower than the No Action Alternative. This slight decrease in late summer flows could affect the ability of these juveniles to outmigrate and use habitats in the estuary, but it would likely be imperceptible. Likewise, water quality modeling indicated there would not be a perceptible change in temperature nor TDG in the lower river with MO1 operations. MO1 includes the *Predator Disruption Operations* measure to reduce predation by reducing birds nesting in the John Day pool; this measure could decrease predation on the proportion of lower Columbia River Chinook salmon that migrate furthest upstream.

*Adult Fish Migration/Survival*

Structural measures such as the *Modify Bonneville Ladder Serpentine Weir* are expected to reduce delay associated with upstream passage. Fallback rates for spring-run may increase slightly with higher spill in April under MO1 as fallback is associated with higher flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). However, regional managers use in-season adaptive management to identify and remedy any excessive fallback. Hydrology and water quality modeling predicts flows, temperatures, and TDG that could affect Lower Columbia River Chinook salmon adult migration and survival would all be similar to the No Action Alternative. Slightly lower outflows in August could affect migration success for fall-run fish.

<u>Lower Columbia River Steelhead</u>

Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

*Summary of Key Effects*

Juvenile survival and travel time would be similar to the No Action Alternative, with similar modeled dam survival, hydrology, and water quality metrics and a potential increase in survival due to predation disruption. Adult migration and survival would be similar to the No Action Alternative, with potentially higher fallback during the higher spill block periods for the spring-run fish.

The results (and change from the No Action Alternative) for metrics for Lower Columbia River steelhead follow:

- Negligible decrease in juvenile project survival, Bonneville Reservoir and Dam (see Snake River steelhead [used as a surrogate]) = (-0.3 percent)
- Bonneville Dam outflows, March to June = (-1 percent to -2 percent)
- Bonneville Dam outflows, August to September (-4 percent to -5 percent), otherwise (-1 percent to +2 percent)
- Spill, Bonneville Dam = April (+3 percent), May (+1 percent), August (-1 percent)
- Temperature, The Dalles Dam, days exceeding state standard = 72 days (+1 day)
- Temperature, Bonneville Dam, days exceeding state standard = 57 days (-1 day)
- TDG, The Dalles Dam, days exceeding state standard = 29 days (+4 days)
- TDG, Bonneville Dam, days exceeding state standard = 64 days (+3 days)

*Juvenile Fish Migration/Survival*

Four of the 23 populations of Lower Columbia River steelhead pass Bonneville Dam on their downstream outmigration to the ocean. Modeling was not available for Lower Columbia River steelhead, so juvenile survival of Snake River steelhead was used as a surrogate of juvenile survival through the Bonneville project (pool and dam) for this portion of the DPS. COMPASS modeling predicts a negligible decrease in juvenile survival as compared to the No Action Alternative. Outflows and temperatures would be similar to the No Action Alternative, within 1 or 2 percent, which would likely not affect juvenile outmigration noticeably. TDG would be slightly higher from the *Block Spill Test (Base + 120/115%)* measure and may influence survival slightly. A decrease in survival of only 0.5 percent was predicted due to higher TDG for Snake River steelhead, which experience a much longer migration through eight projects instead of one for Lower Columbia River steelhead. Any change to Lower Columbia River steelhead with shorter migrations and fewer projects passed would be imperceptible. The *Predator Disruption Operations* measure, as described in the Common Effects section, would reduce predation on outmigration Lower Columbia River steelhead smolts.

*Adult Fish Migration/Survival*

Structural measures, such as the *Modify Bonneville Ladder Serpentine Weir* measure, are expected to reduce delay associated with upstream passage under MO1. April spill at Bonneville Dam under the *Block Spill Test (Base + 120/115%)* measure would be 3 percent higher than the No Action Alternative that could result in slightly higher survival rates for adult steelhead falling back through dams and kelts migrating downstream. Fewer adults used powerhouse passage routes when a spill route was available and overall downstream passage increased when surface passage was available (Normandeau et al. 2014). Kelts that pass via surface passage at Bonneville Dam experience 100 percent survival (Rayamajhi et al. 2012). Most hydrology and water quality metrics predict flows, and temperatures that could affect Lower Columbia River steelhead adult migration, and survival would be similar to the No Action Alternative. Slightly higher TDG exposure could affect adult survival, and lower (4 to 5 percent) outflows in August could affect migration success for summer-run fish.

<u>Lower Columbia River Coho Salmon</u>

See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult Lower Columbia River coho salmon.

*Summary of Key Effects*

Overall, no change or negligible changes would occur for lower Columbia River coho salmon under MO1 due to passage and water temperatures, relative to the No Action Alternative.

*Juvenile Fish Migration/Survival*

Using the surrogate approach, CRS operational changes in MO1 would not change survival rates for Lower Columbia River juvenile coho salmon passing Bonneville Reservoir and Dam. Based on dam-specific COMPASS modeling for Snake River spring-run Chinook juveniles—used as a surrogate species for Lower Columbia River coho juveniles—passage success through the Bonneville project could decline by a fraction of a percent (approximately 0.2 percent). Refer to Snake River spring-run Chinook for surrogate information in Section 3.5.2.3.

*Adult Fish Migration/Survival*

Based on analysis of modeling results, water temperatures around Bonneville Dam specifically may be slightly cooler under all of the MOs compared to the No Action Alternative. Under MO1, the river temperatures near Bonneville Dam that exceed 20°C would occur primarily in August during the early weeks of adult migration and would be similar to the No Action Alternative. Refer to Snake River fall-run Chinook for qualitative surrogate information in Section 3.5.2.3.

<u>Columbia River Chum Salmon</u>

Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia River chum salmon.

*Summary of Key Effects*

MO1 would be similar to the No Action Alternative for chum salmon, with about a 2 percent increase, compared to the No Action Alternative, of years where the flows could not be met without additional drafting of Grand Coulee Dam (additional 2 out of 80 years). Juvenile outmigration could be slightly slower due to decreased outflows in March, and a negligible proportion that pass Bonneville Dam would experience decreased survival at that project. Adult migration and survival would likely be similar to the No Action Alternative. These would be negligible effects to chum salmon.

*Larval Development/Juvenile Rearing*

How operations under MO1 affects the ability of Grand Coulee Dam to provide winter flows to protect chum redds below Bonneville Dam and provide sufficient access to habitat was calculated using hydrology modeling. Under MO1, chum flows would be met in 90 percent of years, compared to 92 percent of years in the No Action Alternative. In years when additional releases from Grand Coulee for chum would be needed, the average additional volume needed would be 0.13 Maf. MO1 would result in 2 percent more years where chum flows would not be met, and decision-makers would have to decide whether to increase risk to chum eggs or reduce spring augmentation flows for spring migrating juvenile salmon.

Maintaining water saturation of 105 percent TDG or less from November 1 to April 30 appears to provide a sufficient level of protection to chum salmon eggs and sac fry incubating in the gravel downstream of Bonneville Dam in the Ives/Pierce Island Complex. In MO1 under the *Block Spill Test (Base + 120/115%)* measure, chum sac fry would be exposed to TDG above 105 percent in 7 out of 80 years, and those exceedances are all in the mid-late April timeframe. This is two more years than in the No Action Alternative.

*Juvenile Fish Migration/Survival*

Chum salmon encounter only one CRS project, Bonneville Dam, so none of the structural measures described in common effects for juvenile salmon and steelhead would apply to these fish, and only a small proportion of spawning occurs above Bonneville. As there is no direct estimate of Bonneville Dam survival specific to juvenile chum, juvenile model metrics for Snake River spring-run/summer-run Chinook salmon are used as a surrogate to estimate any change in juvenile survival for the portion that pass Bonneville Dam. Under MO1, COMPASS modeling of the surrogate species indicates that MO1 would be similar to the No Action Alternative.

*Adult Fish Migration/Survival*

The structural measure, *Modify Bonneville Ladder Serpentine Weir*, would improve passage for the portion of chum that pass this project, but most chum spawn downstream of Bonneville Dam. Migration of chum into the Columbia River is in October and November. Bonneville Dam average monthly outflows would be the same as the No Action Alternative in these months and about 2 percent higher in December under MO1.

**Other Anadromous Fish**

***Pacific Eulachon***

*Summary of Key Effects*

Effects of MO1 would be similar to the No Action Alternative for juvenile eulachon migration and survival.

Compared to the No Action Alternative, MO1 would have no change in the time between the peak spawning runs, egg development, and larval emergence. The spring freshet that disperses larvae to adequate food sources would continue to be highly variable, with an average of 168 days between spawning temperature triggers and peak flows (158 days in high-flow years, and 156 days in low-flow years).

Spring flow rates would be expected to be about 1 to 2 percent lower during outmigration compared to the No Action Alternative, so any changes affecting eulachon feeding would be negligible.

Eulachon would continue to migrate into the Columbia River from November through March, with specific dates of migration and spawning based on a variety of environmental factors, including temperature, high tides, and ocean conditions (NMFS 2017). Modeled data for MO1 (based on the period of record for Bonneville Dam tailwater temperatures) indicate that temperatures would not be substantially different from the No Action Alternative (all temperatures would be within 0.6 degree Celsius of the No Action Alternative). Spawning locations and substrate conditions would not be expected to differ from the No Action Alternative. Although migration as far upstream as Bonneville Dam is unusual, structural measures at the fish ladders could make passage easier for eulachon.

Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation rates on eulachon, whereas at lower flows, birds tend to switch to marine prey. Under MO1, there would be negligible change (0 to 3 percent) in survival rates due to predation across all months and water year types.

#### ***Green Sturgeon***

*Summary of Key Effects*

The Columbia River use by green sturgeon is primarily foraging habitat for adults and subadults. Key effects of MO1 are focused on how flows and temperatures influence the cues for entering the Columbia River as well as the availability and distribution of food sources. Overall, the lower Columbia River would continue to provide good foraging and rearing habitat for green sturgeon, with negligible decreases in summer foraging habitat from flows that would be 4 to 5 percent lower than the No Action Alternative in August.

#### ***Pacific Lamprey***

Summary of Key Effects

MO1 has several measures that are designed specifically to benefit lamprey: *Lamprey Passage Structures*, *Turbine Strainer Lamprey Exclusion*, *Bypass Screen Modifications for Lamprey*, and *Lamprey Passage Ladder Modifications*. These measures are proposed structural improvements that include converting extended-length submersible bar screens to submersible bar screens, expanding the network of lamprey passage structures to bypass impediments in fish ladders, changing the design for turbine cooling water strainers, and replacing turbines for safer fish passage, among other physical modifications to reduce fish injury and mortality.

As described for the No Action Alternative, upstream and downstream passage at the mainstem Columbia River and Snake River Dams has been the greatest influence on population decline and reduced distribution of Pacific lamprey. The most substantial benefit of MO1 would be the improvements to get fish to enter the fish ladders; this would occur through expanding the network of lamprey passage structures and modifying fish ladders to incorporate lamprey passage criteria into the structural modifications.

Larval Development/Juvenile Rearing

MO1 includes manipulation of the John Day Reservoir for predator disruption under the *Predator Disruption Operations* measure. Water levels would be increased during nesting season and then dropped back down to the normal operating pool. Depending on dewatering rates, larval lamprey could become stranded if they are rearing in the shallows when the pool level would be dropped. Otherwise, ramping rates and dewatering issues would be the same in this alternative as for the No Action Alternative.

Juvenile Fish Migration/Survival

Water temperatures and physical structures affect juvenile lamprey during their outmigration. The *Modified Dworshak Summer Draft* measure would cause changes in temperature downstream in the lower Snake River compared to the No Action Alternative. At Lower Granite Dam, temperatures would be cooler June to August 1, warmer early August to mid-September, and cooler in mid-September to October. Temperatures could increase up to 4 degrees

Fahrenheit with rapid fluctuation to about 3 degrees Fahrenheit cooler in about a week. Lower Granite Dam results in several days warmer than 20°C compared to none in the No Action Alternative which would be a minor adverse effect. The effect continues downstream and would be attenuated with distance from Dworshak Dam. The lower Columbia River temperatures would be similar to the No Action Alternative. Compared to the No Action Alternative, the number of days exceeding the state temperature standards in the lower Snake River would be as follows:

- Lower Granite Dam: 22.6 days (18.2 more than the No Action Alternative)
- Little Goose Dam: 45.6 (8.6 more than the No Action Alternative)
- Lower Monumental Dam: 54.4 (7.2 more than the No Action Alternative)

Several measures would improve conditions for outmigrating juveniles. Proposed actions include the following:

- *Bypass Screen Modifications for Lamprey* measure: Converting the extended-length submersible bar screens to submerged traveling screens would substantially reduce mortality due to lamprey being trapped against intake screens (i.e., impingement). Because turbine routes are generally associated with lower survival of migrating juvenile salmon and steelhead, they are equipped screens that help bypass these fish to higher survival routes. Some of these screens are made of closely spaced bars rather than a mesh material. These screens are effective at diverting juvenile salmon and steelhead, but juvenile lamprey are often so small they become impinged between these bars. The modification or replacement of these screens with woven mesh or more tightly spaced bar material would reduce lamprey mortality by an unknown amount.
- *Turbine Strainer Lamprey Exclusion* measure: A new design of structure for exclusion of juvenile lamprey from cooling water strainer intakes would substantially reduce or eliminate this pathway of mortality. Turbine cooling water intakes within the turbine scroll case are equipped with a strainer that prevents debris from entering the cooling water system. However, these strainers do not prevent the entrainment of juvenile lamprey and some juvenile salmon and steelhead. An unknown number of these fish are entrained and die in the cooling system each year. The retrofitting of these intakes with hoods that allow water flow but prevent debris and juvenile fish entry would reduce lamprey losses in the cooling water intake system.
- *Additional Powerhouse Surface Passage* measure: Additional powerhouse surface passage at Ice Harbor and McNary Projects (described in the Common Effects to Salmon and Steelhead section) could change the dynamics of lamprey passage. Lamprey migrate fairly deep in the water column and most pass the dams via the powerhouse, however a slightly higher percentage of lamprey would be expected to pass via the surface routes instead of the turbines in relation to the No Action Alternative, although the relative effect on lamprey is not known.
- *Improved Fish Passage Turbines* measure: Replacing turbines at the John Day Project (also defined in the Common Effects to Salmon and Steelhead section) with a newer design of turbine would improve conditions for fish passage and reduce the injury rate for lamprey.

Because of the high degree of uncertainty surrounding how many juvenile lamprey are lost or injured on their downstream migration, and the relative effects to juvenile lamprey due to passage via surface routes or turbine routes, it is difficult to quantify the improvement represented by all of the measures. For fish that encounter multiple dams on their migration downstream, reducing the total number of hazards would increase their probability for survival to the adult life stage.

<u>Adult Migration/Survival</u>

Structural measures in MO1 that were intended to provide improvements to adult lamprey passage and survival include:

- *Lamprey Passage Structures* and *Lamprey Passage Ladder Modifications* measures at Bonneville, The Dalles, and John Day Projects: Fish ladders at most of the projects were designed primarily for salmon and steelhead passage. More recent work has shown some parts of the structures create migration delays and even barriers for lamprey.
- *Modify Bonneville Ladder Serpentine Weir* measure: At Bonneville Dam's Bradford Island and Washington Shore ladder flow control sections, the baffles that help slow velocities and control flows do not allow for direct line movement of fish passing the dam, but requires fish to weave through the baffles. This construction reduces fish passage efficiency and increases migration delays. The modification of these baffles would include replacing baffles allow for direct faster movement through the ladder baffles from this section of the ladders and replace them with baffles that have in-line vertical slots and orifices. This measure has the potential to increase adult salmon and steelhead survival by reducing upstream travel times and higher conversion rates. A similar modification at John Day Dam, the only other CRS dam to use this type of ladder, resulted in major passage time reductions for salmon and steelhead. Similar improvements are expected for Bonneville Dam. In addition, these improvements would reduce migration delays and barriers for Pacific lamprey.

Each structural measure in MO1 that targets lamprey is intended to increase their dam passage efficiency either by getting fish to enter rather than turn back from the fishway, or to increase successful passage to the upstream end to continue migrating. Effectiveness of the measure would vary by dam. At Bonneville Dam, the measures that aid in getting adult fish into the fishways would be a substantial improvement over the existing conditions of only 44 to 50 percent of lamprey entering the fishways. If the structural measures were successful at Bonneville Dam, the action agencies expect an improvement to approximately 70 percent of lamprey entering the fishways. Additionally, the *Modify Bonneville Ladder Serpentine Weir* measure would substantially improve upstream passage efficiency for lamprey at Bonneville Dam. Lamprey passage structures would likely represent more overall benefit than ladder improvements because the lampreys do not make it into the structures at Bradford Island fishway. Improvements at John Day Dam ladders to improve lamprey entrance into the fishway resulted in increased efficiency of 46 percent to 83 percent. Dynamics at each dam are very different, so the action agencies cannot infer directly across projects, but lamprey do see improvements in overall dam passage efficiency with improvements in ladder entrance efficiency.

The Dalles Dam has relatively good lamprey passage, so the increment of improvement would be helpful, but not as great as what is expected at Bonneville Dam. At John Day Dam, lamprey passage is about 60 to 70 percent; additional work for the lamprey passage structures on the south and extension on the north would continue to moderately improve overall dam passage efficiency incrementally. Other measures to improve fish passage include the following:

- The *Lower Granite Trap Modifications* measure would improve lamprey passage issues at the adult trap by allowing lamprey to pass when scientists are not trapping fish. This measure is described in detail in the Common Effects to Salmon and Steelhead section.
- The *Lower Snake Ladder Pumps* measure at Lower Monumental and Ice Harbor Dams would be expected to benefit lamprey because this has been successful at Little Goose and Ice Harbor Dams. This measure is described in detail in the Common Effects to Salmon and Steelhead section.
- The *Lamprey Passage Ladder Modifications* measure would involve modifications to The Lower Monumental Project that include diffuser grate plating. This action has been completed at all other ladders except Lower Monumental Dam and has demonstrated slight benefits to lamprey passage.

The overall expected improvements in lamprey passage efficiency should decrease susceptibility to physical stress and mortality, and shorter holding time is beneficial to the fish. These structural measures for lamprey are expected to provide a substantial benefit to the distribution of Pacific lamprey in the Columbia Basin. All of the structural measures to reduce losses would have benefits to the population and recruitment in the next generation. Pacific Lamprey do not exhibit strong homing tendencies to their river of natal origin, hence, improved survival rates from adult return to juvenile outmigration would benefit the north Pacific population rather than only the Columbia Basin.

#### ***American Shad***

<u>Summary of Key Effects</u>

No change is anticipated to juvenile shad because plankton communities and shoreline habitat are not changing in MO1. The proportion of adult shad counted at Bonneville Dam that migrate upstream past McNary Dam is expected remain similar under this alternative.

## RESIDENT FISH

### Region A

#### ***Kootenai River Basin***

<u>Summary of Key Effects</u>

MO1 would have the same key effects as the No Action Alternative. Spring water temperatures would continue to be too cold for the development of many of these aquatic species. Spring flows would also continue to increase at an unnaturally low rate, thereby delaying and reducing productivity associated with inundated riparian and varial zone habitats in the river corridor from the dam to Kootenay Lake in British Columbia. These reduced flow rates would also continue to limit productivity and may adversely impact kokanee and their food sources downstream of Libby Dam.

Under MO1, fluctuations in discharge from Libby Dam in the winter from the *December Libby Target Elevation* measure would continue to adversely affect benthic organisms. Cottonwood seedlings would continue to have variable survival depending on timing, stage and duration of spring flows, along with winter stage during the ensuing winter. In addition, the discharge regime from Libby Dam would not provide for successful burbot recruitment, and spring water temperatures would be too cold to allow for proper larval development.

<u>Habitat Effects Common to All Fish</u>

MO1's *Modified Draft at Libby* measure would also have a lower rate of flow increase from Libby Dam between mid-April and mid-May than the No Action Alternative. This decrease in flow rate combined with more cold water on wet years could result in later warming that would translate to a greater delay in growth and development of resident fish and their food resources.

MO1's *Modified Draft at Libby*, *December Libby Target Elevation,* and *Sliding Scale at Libby and Hungry Horse* measures would increase slightly the potential and area for cottonwood and willow seeding and recruitment compared to the No Action Alternative. Under MO1 there would be a slight increase in the number of days when winter peak stages would not exceed the water levels needed for cottonwood and willow seeding at Bonners Ferry.

<u>Bull Trout</u>

Under MO1, Lake Koocanusa would be above elevation 2,450 feet for seven more days on average (15 percent) than the No Action Alternative during the summer when productivity is critical. The expected result would be slightly higher productivity and improved food availability than under the No Action Alternative.

The average minimum annual pool elevation of Lake Koocanusa under MO1 would be approximately 2 feet lower in dry and average years than under the No Action Alternative. The expected result would be more frequent annual dewatering and decreased benthic insect production, which may result in a decrease in bull trout growth and/or survival. The annual maximum elevation of Lake Koocanusa under MO1 would be higher as shown by the 1.6-foot higher median July 31 elevation than under the No Action Alternative and may result in slightly higher terrestrial insect deposition under this alternative.

Water temperature in Lake Koocanusa under MO1 would not be substantially different from that under the No Action Alternative. However, under MO1, the higher winter pool elevations in wet years associated with flood risk management and power generation could result in a colder thermal mass that warms slowly. In dry years, lower pool elevations would result in quick springtime warming of the forebay, and thus warmer discharge temperatures during the spring and summer when compared to the No Action Alternative.

Under MO1, Libby Dam would provide discharge of 20 kcfs or greater for 12 days, on average, during the spring freshet, which is one day less than mean for the No Action Alternative. The mean flow rate from May 15 to June 15 under MO1 would be slightly less than under the No Action Alternative and would be insufficient to mobilize or reshape tributary deltas that can prevent bull trout access during low flows in the fall spawning season.

While MO1 would have somewhat lower discharges from Libby Dam than the No Action Alternative, these reduced flows would provide slightly more usable habitat.

Kootenai River White Sturgeon

Effects of MO1 would not be different from those of the No Action Alternative for Kootenai River White Sturgeon.

Other Fish

The minimum annual pool elevation of Lake Koocanusa under MO1 would be approximately 2 feet lower in dry and average years than under the No Action Alternative. This would result in reductions in insect larvae production and food available for resident fish species, which may decrease growth and survival of these species. However, in wet years, MO1 would provide a shallower draft and may be more beneficial to benthic insect production during those years. The annual maximum elevation of Lake Koocanusa under MO1 would be higher than under the No Action Alternative as shown by the 1.6-foot higher median July 31 elevation and may result in slightly higher terrestrial insect deposition. Under MO1, higher pool elevation in the early winter followed by aggressive drafting (higher outflows) associated with flood risk management and power generation could result in a warmer winter flows and colder early spring flows than the No Action Alternative. The 75th percentile elevation is slightly higher than the No Action Alternative and this larger cold thermal mass warms slightly slower. On dry years, a lower pool elevation would result in quicker springtime warming of the forebay, and thus warmer discharge temperature during spring and early summer.

MO1 would have slightly lower discharges from Libby Dam for the period May 15 to September 30 than the No Action Alternative and would provide slightly more usable habitat for juvenile and adult rainbow trout than the No Action Alternative. High and variable flows can interrupt burbot spawning migrations, while low (4 kcfs) and stable winter flows encourage successful burbot spawning. Median flows under MO1 as measured at Bonners Ferry would be higher than No Action Alternative flows in January through April and would be less likely to provide conditions conducive to successful burbot recruitment.

### ***Hungry Horse/Flathead/Clark Fork Fish Communities***

<u>Summary of Key Effects</u>

The key effects of MO1 are largely biological responses to changes in Hungry Horse Reservoir elevations and outflows to provide additional water supply under the *Hungry Horse Additional Water Supply* and *Sliding Scale at Libby and Hungry Horse* measures. Lower elevations through the summer decrease food supply for fish with slight reductions in plankton production and surface area for summer terrestrial insects. Benthic insect production important to fish would be appreciably decreased under MO1. Lower surface elevations could also increase issues with predation/exploitation risk as fish migrate into and out of tributaries to fulfill their life cycles, and increased outflows in summer would likely result in increased entrainment of zooplankton and fish out of Hungry Horse reservoir. Increased flows in the South Fork Flathead River would be attenuated with flows from the mainstem Flathead River but would still result in higher summer flows that would increase velocities. These velocity increases could decrease native fish habitat suitability in that reach. MO1 would have negligible effects on Flathead Lake, lower Flathead River, or Clark Fork fish.

<u>Habitat Effects Common to All Fish</u>

In wet and average water years the reservoir would still reach near full pool (elevation 3,560 feet) by early July in most average years and mid-July in wet years. However, in these year types the median elevation at the end of September would be 3,546 feet, or about four to five feet lower than the No Action Alternative. In dry years the reservoir would still approach full pool, miss filling and typically become drawn down faster in the same pattern as the No Action Alternative, but the dry year elevation would be a median of a foot lower than the No Action Alternative dry year. All year types considered, there would be a 69 percent annual probability of reaching elevation 3,559 feet by July 31, or six years more out of 100 that would not reach full compared to the No Action Alternative. In extreme years, MO1 could be up to 11 feet lower than No Action Alternative by the end of September. In fall and winter months, MO1 would be lower than No Action Alternative. The fall and winter elevations would follow the same pattern as modeled, but the difference between No Action Alternative and MO1 would only be up to six or seven feet lower than No Action Alternative. The rate of drop would at times be steeper than No Action Alternative through these months.

Lake elevation in the warm summer months determines the volume of reservoir that would be available to produce plankton (euphotic zone). With lower summer elevations, the euphotic zone decreases slightly under MO1. In June, MO1 and No Action Alternative are similar, but by July they begin to diverge with MO1 zone becoming less than the No Action Alternative. By September under MO1, the euphotic zone is about 32,000 acre-feet smaller than the No Action Alternative in wet and average years, and about 11,500 acre-feet smaller in dry years. The decrease ranges from one to three percent of the total volume. See Appendix E for a table of the calculated euphotic zone predictions under MO1.

Drawdowns any time during the year affect the production of insects that live on the bottom of the reservoir. As reservoir elevations drop, insects that have established in this zone can become dewatered. The insect eggs would have been deposited within the euphotic zone described above. If reservoir levels drop, that zone remains the same thickness and drops with the surface level, but there would be no insects deposited at the lower elevation that is now the euphotic zone. As the elevation drops, the surface for benthic insect production gets smaller. MO1 drops faster than the No Action Alternative in the summer and would be at lower elevation through the following fall and winter. This would result in less area for benthic insect production than the No Action Alternative. Some of the larger aquatic insects have long life cycles that require overwintering where they were deposited; lower winter elevations would reduce the survival of these important insects. Table 3-62 shows size of the lake (surface area in acres) at the end of each month. Using surface area as an index for benthic area, MO1 surface area would decrease by 200 to 800 acres compared to the No Action Alternative, or about 2 to 4 percent from October through February in all year types, and in dry and average years March through May would have similar decreases. Additionally, in dry years the summer months would have surface area 4 percent to 5 percent lower than the No Action Alternative, or a difference of about 530 to 820 acres. The large bays at the upper end of the reservoir could experience a proportionally higher rate of dewatering with dropping levels over the summer due to more shallow slopes. An equal drop in elevation would result in a larger dewatered benthic surface area, therefor actual lost benthic production would be more than surface area indicates, and considerable mortality of established benthic macroinvertebrates would be expected.

Finally, the reservoir elevation determines the surface area available for terrestrial insects to land on the water and be available for fish food in summer, as well as influencing the proximity of the water’s edge to terrestrial vegetation. Therefore, the availability of some important insects to fish through the winter months the reservoir surface would be about 300 to 800 acres smaller, or 2 to 4 percent smaller compared to the No Action Alternative. In summer months as the elevation decreases faster under MO1 the surface area would be about 100 to 400 acres smaller, or 1 to 2 percent smaller than under the No Action Alternative by the end of summer.

Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry Horse reservoir. The zooplankton enhances food supply in the South Fork Flathead River and along the near bank of the Flathead River but decreases food supply for fish in Hungry Horse Reservoir. Outflows, and therefore zooplankton entrainment, under MO1 would be higher in summer and lower in fall, winter, and spring. These zooplankton are concentrated in the withdrawal zone in summer so the entrainment effect from increased summer outflows would be disproportionate; the 9 percent to 21 percent higher flows would likely represent a higher increase in zooplankton entrainment.

Outflow patterns from Hungry Horse Reservoir can also affect how fish are entrained into the South Fork Flathead River, and the habitat conditions, such as river elevation (stage), velocities, and temperatures in the river. These flow changes continue downstream to affect the main

Flathead River in the same patterns, but somewhat attenuated by the flows in the mainstem Flathead. Temperatures in summer are regulated with a selective withdrawal structure that is operated to release water of a temperature that favors native fish. Under MO1 operations, outflows would be from nine to 21 percent higher than the No Action Alternative in July to September, similar in October, and then generally lower than the No Action Alternative through the fall, winter, and spring months. The winter flows would be one percent to 12 percent lower than the No Action Alternative and April to June flows would be four to 17 percent lower.

The temperature control structure would still operate in the summer months as in the No Action Alternative so changes in outflows in this timeframe would not affect summer temperatures downstream.

In the Flathead River down to Flathead Lake, habitat suitability under the No Action Alternative is a key issue due to unnaturally high flows in the summer and winter. Under MO1, July to September flows would be 2 to 10 percent higher than the No Action Alternative summer flows, and winter flows in MO1 would be slightly lower than the No Action Alternative. Spring peaks would also be slightly lower than the No Action Alternative. Winter flows lower than the No Action Alternative would improve winter habitat suitability slightly, and spring peaks only slightly lower than the No Action Alternative would continue to occasionally provide flushing of sediments from gravels to maintain habitat.

The winter water temperature warming influence from the contribution of the South Fork Flathead would be slightly less due to slightly lower winter flows out of Hungry Horse. TDG in the Flathead River would be similar to the No Action Alternative, continuing to fluctuate with spill at Hungry Horse dam but generally-speaking, would not exceed 117 percent, which is within a safe zone for fish.

The influence of MO1 changes to Flathead Lake levels and Seli'š Ksanka Qlispe' Dam operations would be minimal compared to the No Action Alternative, and habitat conditions in these areas would be similar as described in the No Action Alternative.

Bull Trout

MO1 conditions would slightly reduce the summer production of zooplankton that provides forage for bull trout and surface area available for summer terrestrial insect feeding. The lower reservoir elevations and steeper drawdowns would result in substantially lower surface area for benthic insect production throughout the year, especially in the bays at the upper ends of the reservoir lobes. Juvenile bull trout moving into the reservoir in the spring rely on the benthic insects until they transition to eating fish. The prey items that adult bull trout eat also consume the benthic insects and may be in poorer condition or less plentiful in areas. This could result in bull trout being in poorer condition.

Lower reservoir elevations in the fall would increase the risk and exposure to predation and angling pressure for upstream migrating bull trout. The sedimentation of tributary deltas currently is not known, but there could potentially be blockages of passage arise with lower elevations as well. These effects would likely be moderate in wet, average, and most dry years with 3 to 4 feet of difference from the No Action Alternative. In extremely dry years there could be much lower elevations (up to 12 feet lower than the No Action Alternative) and more extreme effects in years when the elevations would already be causing access and varial zone issues under the No Action Alternative.

Bull trout entrainment through the dam would likely increase in MO1 due to increased outflows in late summer. Withdrawals in August and September are generally selected from deep in the water column to release the target temperature, and bull trout have been documented in this stratum at this time of year. Entrainment under the No Action Alternative is likely minimal and has not been quantified but would be expected to increase nine to 21 percent under MO1 as modeled.

The number of individual bull trout in the South Fork Flathead River below Hungry Horse Reservoir may increase with greater entrainment, but these would be lost from their spawning populations because they only spawn above Hungry Horse dam but would be unable to ascend back up past the dam once they were flushed downstream of it. Zooplankton available in the South Fork Flathead River may increase in summer with higher outflows. As in the reservoir, food web relationships are important. MO1 would continue to allow for this transitory use by bull trout and other native fish with adequate food. Higher flows may also increase benthic production of food for bull trout prey fish, but increased velocities would result in lower availability of suitable habitat for bull trout.

Summer flows in the mainstem would be higher than the No Action Alternative, further exacerbating issues with habitat suitability. Muhlfield et al. (2011) found even moderate increases in summer flows resulted in substantial decreases in suitable area for bull trout, and that nighttime habitat for subadult bull trout was most sensitive. The 2 to 10 percent increase due to MO1 would reduce bull trout habitat, especially for subadults. The mainstem Flathead River would be similar to the No Action Alternative in winter, with barely perceptible changes (slightly lower) from the No Action Alternative.

Operations of Seli'š Ksanka Qlispe' Dam (Flathead Lake) would be similar to the No Action Alternative, and the bull trout habitat use and life history functions in Flathead Lake, the Lower Flathead River, and Clark Fork River would be similar to the No Action Alternative.

<u>Other Fish</u>

Hungry Horse Reservoir favors a native fish dominated fish community. Juvenile bull trout and adult whitefish, northern pikeminnow, sculpins, and westslope cutthroat trout feed on zooplankton, aquatic insects, and terrestrial insects, and adult bull trout prey on mountain whitefish, suckers, minnows, etc. The food web effects described above would also apply to all of these species of fish in Hungry Horse Reservoir. Slight decreases in zooplankton and reduced summertime feeding of terrestrial insects could reduce food supply slightly in summer. Substantial decreases in aquatic macroinvertebrate due to dewatering events and reduced surface area for production would decrease the food supply for many of these fish.

Westslope cutthroat trout and other native fish spawn in the spring (April through June), so effects on adults migrating into tributaries to spawn would differ from bull trout. Spring spawning fish migrate when reservoir levels are lower and tend to experience longer varial zones with increased exposure to predation. Under MO1 operations, the modeled April and May elevations were five feet and three feet, respectively, lower than the No Action Alternative. By June, the elevation would be similar to the No Action Alternative. Given the modeling error, however, the April and May elevations would likely be 1 to 4 feet lower than the No Action Alternative. Spring spawning fish such as westslope cutthroat trout would experience greater varial zone effects on their way upstream as adults, and could encounter some tributary blockages, but the delta formation of these tributaries is not known. Juveniles typically outmigrate in June when the effects would be similar to the No Action Alternative.

Entrainment from the reservoir would also continue at unquantified levels and could increase in the summer months with increased outflows. Northern pikeminnow and bull trout have been documented at the depths of late summer withdrawal and would be most susceptible to increased entrainment. Westslope cutthroat trout and other fish may experience some increase but would not be expected to be as susceptible to entrainment as bull trout because they are not commonly found at the depths of outlets. Entrainment would be expected to increase nine to 21 percent in the summer months and decrease slightly in winter.

Habitat suitability described for bull trout would be similar for other native fish in the mainstem Flathead River (Muhlfield et al. 2011), with higher summer flows in MO1 resulting in decreased amount of suitable habitat for them in summer.

Effects to fish in Flathead Lake, the lower Flathead River, and Clark Fork Rivers would be similar as described in the No Action Alternative.

#### ***Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River***

Summary of Key Effects

Hydrology modeling showed that Lake Pend Oreille elevations, inflows, and outflows would be the same as the No Action Alternative. Biological relationships were dependent on these parameters, so the key effects of MO1 for bull trout, fish habitat, and other fish species in the Pend Oreille basin would be the same as those described under the No Action Alternative.

### **Region B**

#### ***Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam***

Summary of Key Effects

The Columbia River from the U.S.-Canada border would continue to support a white sturgeon population that spawns successfully but primarily relies on fish manager intervention to survive a recruitment bottleneck; conditions for natural recruitment may be further diminished in a small proportion of years. Retention time is a key metric for most fish species in Lake Roosevelt, influencing food that supports the fish as well as influencing how many are entrained.

Retention time would be lower in winter and early spring, especially in the wet years than the No Action Alternative, decreasing productivity and increasing entrainment. Lake elevations under MO1 would increase risk of impeded redband rainbow trout tributary habitat access and eggs drying out. The portion of kokanee that spawn in tributaries would continue to have access in fall similar to the No Action Alternative. Reservoir operations would continue to result in some level of burbot eggs drying out and the portion of kokanee that spawn on lake shorelines and would increase in MO1 compared to the No Action Alternative. MO1 would continue to support both wild and hatchery-raised kokanee, redband rainbow trout and hatchery rainbow trout as well as non-native warmwater game species such as walleye, smallmouth bass, and northern pike. Northern pike would likely continue to increase and invade downstream, and the lake elevations could decrease the ability for boat-based Northern pike suppression efforts. Rufus Woods Lake would continue to provide habitat for fish entrained from Lake Roosevelt and from limited production of shoreline spawning by some species; entrainment could increase in winter and decrease in summer months. TDG would be similar or less than No Action Alternative. The operational measures that could impact fish include the *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee, Winter System FRM Space, Lake Roosevelt Additional Water Supply* and *Chief Joseph Dam Project Additional Water Supply*.

<u>Habitat Effects Common to All Fish</u>

Median peak outflows under MO1 would follow the same pattern as the No Action Alternative with peaks in early June and another, smaller peak in July. The MO1 flows in early spring through September are about 2 percent to 5 percent lower than the No Action Alternative. December flows are about 4 percent to 6 percent higher than the No Action Alternative. These peak outflows can influence the rate of entrainment from Lake Roosevelt into Rufus Woods Lake. TDG in the Grand Coulee tailwater is also a concern for fish in Rufus Woods Lake. Under the MO1 TDG would be lower than No Action Alternative.

The duration that water stays in the reservoir (i.e., retention time) is a driving metric for the food web in Lake Roosevelt and influences the populations of several fish species.

Under MO1, median retention time would be similar to the No Action Alternative in late spring, summer, and fall. In average years, retention time under MO1 would be 6 percent lower in December and January, and in dry years would be about 7 percent to 8 percent lower in December through February but slightly higher in May. In wet years is when retention time is lowest because more water is moving through the system, and MO1 would reduce retention times even further in these years by up to 10 percent in February and by 3 to 10 percent in the entire period of December through May.

Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely directly on the food source provided by the zooplankton production and higher-level predators such as bull trout prey on these fish. With lower water retention times under MO1 in winter and spring, when retention times are already fairly low, there would be less food available to fish, and they would also tend to follow the food source and crowd down towards the dam, becoming more susceptible to entrainment.

Bull Trout

Under MO1, bull trout in Lake Roosevelt could continue to move to cooler locations in the reservoir and these refuges would remain similar to the No Action Alternative. High flow years would continue to influence bull trout distribution through flushing more of them from the river near the U.S.-Canada border down into Lake Roosevelt. Increased outflows in December could potentially increase entrainment of bull trout, but this would be negligible because of the scarcity of bull trout in Lake Roosevelt.

Bull trout are also sensitive to contaminants that are found in this region and would continue to bioaccumulate contaminants as a top predator, but fluctuation events that mobilize mercury would be the same as the No Action Alternative.

Other Fish

White sturgeon recruitment would be dependent on flows exceeding 200 kcfs and appropriate temperatures in late June/early July. Under MO1, flow over 200 kcfs in June and July would have a slight decrease. These slightly reduced flows at the U.S.-Canada border would result in potentially minor decrease in white sturgeon recruitment window. MO1 reservoir levels would be similar, but slightly lower than the No Action Alternative in June and July. Other factors that would continue to influence sturgeon include predation by fish that are favored by reservoir conditions if larvae are flushed into the Lake Roosevelt. Slightly lower flows in spring could slightly reduce the risk of larvae entering Lake Roosevelt. The uptake of contaminants such as copper closer to the U.S.-Canada border being flushed downstream into the reservoir by high flows would also be slightly lower. Under MO1, recruitment of white sturgeon would continue to be a rare event supplemented by hatchery propagation, as larval sturgeon are captured and raised in hatcheries until they are past the window where recruitment has been shown to fail at a high rate. Once these juveniles are released back into the reservoir they continue to grow and survive well. The reservoir would continue to provide good conditions for growth and survival of these fish.

Wild production of native fish such as burbot, kokanee and redband rainbow trout would continue to provide valuable resources in Lake Roosevelt. As described in the common habitat effects, these fish are the most sensitive to the effects of changing retention times. Under the No Action Alternative an estimated average of over 400,000 fish annually would be entrained, with 30 to 50 percent of them being kokanee, primarily of wild origin. Rainbow trout would be the second most entrained species. Under MO1 operations, increased entrainment would be expected in winter months as the outflows increase over the No Action Alternative and retention times are 7 percent to 10 percent lower. Previous entrainment studies (LeCaire 2000) indicated winter being a period relatively low entrainment; however, the prolonged drawdown period is expected to increase entrainment during this time. In wet years, entrainment would also be higher in March-May (3 percent to 8 percent lower retention time) which could increase entrainment to a moderate effect. Increased entrainment of zooplankton would decrease food availability that is key to winter survival and growth of several fish species including kokanee, juvenile burbot, and other juvenile fish.

For tributary spawning species such as redband rainbow trout and a portion of the wild production of kokanee, tributary access at the right time of year is important. Reservoir drawdown in the spring creates barren tributary reaches through the varial zone, which directly and indirectly impedes migration to and from tributaries and the reservoir. Redband rainbow trout need access tributaries in the spring. Under MO1, reservoir elevations would be lower than the No Action Alternative levels in the critical spawning migration time of April to May in wet and dry years (equaling about 40 percent of years). This would be most critical in wet years (20 percent of years) when the median elevation would be 1,241 feet on April 1, which would be seven feet lower than the No Action Alternative. Migratory impacts, although not well documented, could be severe given the timing and extent of the drawdowns in MO1. Redband rainbow trout spawn in Sanpoil, Blue Creek, Alder, Hall Creek, Nez Perce Creek, Onion Creek, Big Sheep Creek, and Deep Creek. These tributaries higher in the basin are more susceptible to elevation changes because a smaller change in lake elevation would result in a larger area of exposure than tributaries closer to the dam. Additionally, increased exposure during migrations to these tributaries would increase the varial zone effect where migrating fish are more exposed to predation and angling due to lack of cover.

Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible to eggs drying out if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on shoreline gravels September 15 to October 15 and eggs incubate through February. Burbot tend to spawn successfully in depths provided by the No Action Alternative in the Columbia River and in Lake Roosevelt on shorelines near the Colville River in winter with eggs incubating through the end of March (Bonar et al. 2000). MO1, compared to the No Action Alternative, begins dropping 2 months sooner and would likely strand or dewater burbot and kokanee eggs. A higher proportion of eggs at all elevations would be affected.

The portion of kokanee that spawn near the fall water surface elevation are more at greater risk. Fry sometimes also stay in the gravels and could become stranded as well. Burbot spawn later in the winter so would be less affected because the lake level would have already dropped seven feet lower than the No Action Alternative when eggs would be deposited. However, this same mechanism would also decrease habitat available compared to the No Action Alternative. The wet years would have steeper and deeper reservoir draft than the No Action Alternative and would result in increased stranding of burbot eggs. Lake elevations influence river stage clear up to the U.S.-Canada border, so burbot that spawn in the rivers would experience the same patterns of dewatering, but at lower magnitudes as the lake effect lessens with distance.

Kokanee are very sensitive to water temperature, and during summer are found at depths below 120 m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is very weakly stratified but does have suitably cool water at this depth along with suitable levels of DO. Lake whitefish and mountain whitefish also likely use this cool water in the summer.

Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish, crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all tolerate a wide range of environmental conditions and would continue to contribute to the fishery community under MO1, and continue to adversely impact native species via predation. The invasion downstream by northern pike is of concern, and the Lake Roosevelt Co-Managers are actively suppressing pike populations using gillnets set by boats as soon as they can get on the water in the spring until the boat ramp becomes unusable at an elevation of 1,235 feet. Under the No Action Alternative this occurs on April 15 in wet years. Boat ramp access would remain useable in dry and average years. Under MO1 in wet years, this would occur about six days 6 days sooner and preclude the ability for the pike suppression efforts for that period. For estimation purposes, one crew typically removes about 100 pike per week and they would operate three crews (Colville Tribe unpublished data), so opportunity loss of up to about six days under MO1 could result in an estimated 300 pike not removed. It should be noted that this is applicable to only one specific boat ramp, but the middle of Lake Roosevelt area becomes inaccessible earlier, at lake elevation 1,245’. Additionally, outflows and retention time would continue to influence the entrainment and downstream invasion of non-native gamefish below Chief Joseph Dam where ESA-listed anadromous salmonids would be susceptible to predation by them. During the time when pike juveniles would be most susceptible to entrainment (May to August), retention time under MO1 would be similar or slightly higher so entrainment risk for pike would be similar to the No Action Alternative or slightly lower. However, as adult pike distribution increases downstream in the reservoir, adults and juveniles both would become more susceptible to entrainment and the increased winter outflow would increase entrainment.

Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt would experience similar effects as their native counterparts except for spawning and early rearing effects. In addition, the net pen locations are situated where the water quality can be affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG, and their eventual recruitment to the fishery can be affected by retention time coupled with reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May. Under the MO1, the water quality at these locations would be similar to the No Action Alternative, and the water retention time in May would be either similar or slightly higher so entrainment risk would be the same as the No Action Alternative or slightly less. The operators strive to release these fish to coincide with the initiation of reservoir refill when outflows are reduced, which under MO1 would be the same as the No Action Alternative, so these fish would continue to be release when water quality conditions would be suitable.

The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter drawdown periods. The earlier start to winter drawdown in MO1 may increase entrainment and boost populations in Rufus Woods Lake, where decreased outflows in August and September likely would decrease entrainment. This lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short water retention time and low productivity. High flows during late spring and early summer would continue to flush eggs and larvae from protected rearing areas similar to the No Action Alternative, but slightly lower magnitude. Median peak outflows occur in early June and would be about 2 2 percent lower than the No Action Alternative. TDG in the Grand Coulee tailwater is a concern for fish in Rufus Woods Lake; modeling showed TDG would be slightly lower than the No Action Alternative.

#### *Chief Joseph to McNary Dam*

Summary of Key Effects

Key effects to fish and aquatic resources from MO1 would be similar to the No Action Alternative for most species. Additional effects under MO1 include slightly reduced spring freshet flows that may lead to minor reductions in white sturgeon spawning success, and slight increases in temperatures during northern pikeminnow and smallmouth bass rearing periods. The operational measures that could impact fish in Region B include the *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee, Winter System FRM Space, Lake Roosevelt Additional Water Supply* and *Chief Joseph Dam Project Additional Water Supply*.

Habitat Effects Common to All Fish

Common habitat effects of MO1 are similar to those identified for the No Action Alternative with the exception that flows would be slightly reduced in the spring freshet and water temperatures slightly increased during the late summer and early fall. These changes would have minor effects to fish species in the Columbia River.

Bull Trout

Key effects to bull trout under MO1 would not differ from the No Action Alternative. Bull trout would continue to use mainstem habitats of the Columbia River from November through July for foraging, migration, and overwintering.

Other Fish

Effects to white sturgeon under MO1 are not expected to change from those under the No Action Alternative except that spring freshet flows would be reduced slightly, leading to minor reductions in white sturgeon spawning success. The number of days when flows at McNary Dam would be above 250 kcfs would be reduced by about half a day from 9.3 to 8.8 days during May through July.

Key effects of MO1 relative the No Action Alternative for additional fish resources would include a slight increase of in late summer water temperatures during the rearing period for northern pikeminnow and smallmouth bass. This increase may lead to better growth and survival for these and other species with similar life history requirements. Other effects would be similar to the No Action Alternative.

**Region C**

***Snake River Basin***

<u>Summary of Key Effects</u>

Key effects from MO1 that differ from those found under the No Action Alternative include warmer water temperatures during August and slight increases in TDG April through July from operational measures such as *Block Spill Test (Base + 120/115%)* and *Modified Dworshak Summer Draft*.

<u>Habitat Effects Common to All Fish</u>

Common habitat effects of MO1 are similar to those identified for the No Action Alternative with the exception of the changes discussed in the section above.

<u>Bull Trout</u>

Effects of MO1 to bull trout within the Snake River Basin that differ from the No Action Alternative include a reduction in cooling water releases from Dworshak reservoir in August that would result in an increase in water temperature in the Clearwater and Snake Rivers. However, this would have minor adverse effects to bull trout as they migrate out of mainstem habitats prior to these releases and should be in tributary habitats when this operation occurs. These same cold water releases would start earlier in the year than under the No Action Alternative and would reduce water levels in Dworshak Reservoir and potentially impact bull trout migration access to tributaries in late June and early July.

<u>Other Fish</u>

Effects to white sturgeon under MO1 are not expected to change from those recorded under the No Action Alternative except that slightly higher water temperatures would occur in August as a result of a decrease in the release of cooling water from Dworshak Reservoir. This increase in temperature may increase mortality to white sturgeon on low water years. Mass mortality events and increased single mortalities are observed more frequently during high temperature events, often coupled with sockeye mortality events.

Key effects of MO1 relative the No Action Alternative for additional fish resources would include a slight increase of in late summer water temperatures during the rearing period for northern pikeminnow, smallmouth bass and other cool and warm water fish species, and changes in TDG during spill in the spring, summer, and fall. Water temperatures would increase in August by as much as 4 degrees Celsius. This increase would contribute to better growth and survival for these and other species with similar life history requirements.

Increases in spill under MO1 would increase TDG slightly during the spring and summer spill season and reduce TDG considerably in the fall with the early cessation of spill. High TDG could have adverse effects to early life stages of resident fish that are not able to compensate for high TDG by changing depth. Other effects would be similar to the No Action Alternative.

**Region D**

***Mainstem Columbia River from McNary Dam to the Estuary***

Summary of Key Effects

Bull trout would continue to use the Columbia River in limited numbers and seek thermal refugia available at the mouths of tributaries. White sturgeon could continue to successfully reproduce in years with adequate flow and temperature conditions; recruitment failure has continued to occur in the Columbia basin and the causes are not well understood. The *Block Spill Test (Base + 120/115%), Increased Forebay Range Flexibility, Additional Powerhouse Surface Passage,* and *Improved Fish Passage Turbines* are measures that could provide a beneficial effect to fish on the Mainstem Columbia River from the McNary Project to the estuary.

Habitat Effects Common to All Fish

Outflows from McNary Reservoir influence some of the fish relationships described in this section. Peak spring flows affect habitat maintenance for some species. Modeled monthly median outflows for MO1 are shown below. The percent change compared to the No Action Alternative is shown in parentheses.

- April: 187187187187187,600 cfs (-2 percent)
- May: 254254254254254,300 cfs (-2 percent)
- June: 282282282282282,400 cfs (-1 percent)
- July: 195195195195195,800 cfs (-1 percent)

Other flow parameters referred to in this section refer to outflows of McNary Dam, which are indicative of flows on downstream through the other Projects.

Bull Trout

Bull trout are known to use the mainstem Columbia River to move between tributaries and have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et al. 2016). Water temperature is the most important habitat factor for bull trout in the mainstem Columbia. Under MO1, bull trout would continue to use the mainstem Columbia for migration between tributaries, as well as tributary mouths for passage and thermal refugia.

Adult bull trout move downstream during fall and overwinter in reservoirs (October to February) (Barrows et al. 2016). Although bull trout successfully move between areas on the mainstem, their migration can be delayed at the dams. MO1 includes a structural measure for additional spillway passage at McNary Dam. The *Additional Powerhouse Surface Passage* measure would be in operation from March 1 through August 31, and could slightly improve bull trout downstream passage, but the majority of adult bull trout would have moved out of the mainstem by the time this surface passage route would be in use.

Passage through turbines can cause injury or mortality, as well as migration delays. MO1 includes the *Improved Fish Passage Turbines* measure, which would improve survival (Deng et al. 2019). At John Day, turbine replacement would provide safer passage for any bull trout that move through the dam.

Bird predation on bull trout would continue to occur under MO1. New surface bypass designs under MO1 could shift bull trout into areas that are more susceptible to bird predation.

<u>Other Fish</u>

Under MO1, white sturgeon spawning and recruitment would be similar to the No Action Alternative, with a range of 48 days (2015) to 74 days (2012) with suitable conditions. The number of days with optimal embryo incubation (12°C to 14°C) would also be similar to the No Action Alternative, range from 6 days (2013) to 27 days (2011). In years of low flow conditions, water temperatures could increase beyond the suitable range by early June, resulting in little or no recruitment.

Flows for successful sturgeon spawning and recruitment were analyzed based on the McNary tailrace. Since lower Columbia dams are run-of-river, the outflow at McNary Dam correlates with the outflows at John Day, The Dalles, and Bonneville Dams. Flows of at least 250 kcfs from April 1 to July 31, coupled with suitable temperatures, provide favorable spawning and rearing conditions. Compared to the No Action Alternative, there could be a slight reduction in the number of years with recruitment success under MO1. Model results indicate two fewer days of suitable conditions in median years and three fewer days in high flow years. Low flow years would likely not provide sufficient time with suitable flows for recruitment to occur, similar to the No Action Alternative.

White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse substrates (Parsley et al. 1993). Minor changes in outflow under MO1 would not be large enough to cause discernable velocity changes that would affect sturgeon spawning habitat.

Lack of effective upstream white sturgeon passage for all age classes decreases the connectivity of the population (Parsley et al. 2007). Under MO1, a measure to improve fish passage at Bonneville Dam would likely improve potential passage for sturgeon. The vertical slot fishway would make it easier for sturgeon to pass upstream.

Turbine units at dams can cause injury and mortality in juvenile and adult sturgeon. Under MO1, improvements to turbines at John Day would reduce injuries and mortality of juvenile sturgeon (Deng et al. 2019).

White sturgeon larvae are adversely affected by TDG. Studies have shown high rates of altered buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al.

1998). Adults are more able to compensate for increased TDG by moving to lower depths, but larvae in shallow water would be more affected. Under MO1, TDG rates would be similar to the No Action Alternative.

Changes in a pool or tailrace elevation can affect juvenile white sturgeon through stranding in shallow water. Under MO1, pool elevations would be about 1 foot higher in the John Day pool from late March through early June (due to bird predation measures), and the drop in early June could strand larvae.

Under MO1, lower flows at Bonneville during dry years in May and August could potentially increase pinniped predation rates, but it is also likely that sturgeon are avoiding the tailrace due to predation pressure.

Resident fish such as sculpin, walleye, and smallmouth bass are predators of embryo and age-0 white sturgeon. Under MO1, predation would continue to affect early life stages of white sturgeon.

Reservoirs in the lower Columbia may be in maturation, in which sedimentation and invasive aquatic plants could reduce habitat value for sturgeon through changes in predation, food availability, and suitability for invasive species. This trend would not be expected to change under MO1.

Under MO1, no changes to resident fish communities would be expected. As shown above, outflow rates below McNary Dam would be very similar to the No Action Alternative. Water quality and food availability would also be similar to the No Action Alternative.

Conditions that promote lower water temperatures and higher spring flows tend to lower the survival rates of warmwater game fish, potentially lowering populations of predators on salmon and steelhead. MO1 would be expected to continue supporting warm water game fish at levels similar to current conditions.

## MACROINVERTEBRATES

Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under MO1. For more detailed information on the effects of MO1 on aquatic invertebrates and implications on food web interactions see the Habitat Effects section of these respective fish community analyses in the Resident Fish section under the applicable region.

### Region A

Project operations under MO1 would affect the aquatic environments provided by Hungry Horse Reservoir, South Fork Flathead River, Flathead River, Flathead Lake, lower Flathead River, Clark Fork River, Lake Pend Oreille, Pend Oreille River, Lake Koocanusa, and the Kootenai River. These include the *Modified Draft at Libby*, *December Libby Target Elevation, Hungry Horse Additional Water Supply,* and *Sliding Scale at Libby and Hungry Horse* measures.

At Hungry Horse reservoir, the varial zone that provides benthic insect production would be appreciably reduced due to steeper drafts in the summer and lower elevations through the winter months, and aquatic insects in this zone would become dewatered faster than under the No Action Alternative. The reservoir would miss filling in six more years out of 100 compared to the No Action Alternative, and the elevation at the end of September would be 4 to 5 feet lower than the No Action Alternative. With lower summer elevations the euphotic zone for summer zooplankton production would also decrease by 1 percent to 3 percent, and zooplankton being carried downstream out of the reservoir and into the South Fork Flathead River would increase with higher outflows of nine to 21 percent in the summer months. Zooplankton entrainment would generally be lower than the No Action Alternative in spring, fall, and winter. These outflows can increase zooplankton levels and wetted area for macroinvertebrate production in the South Fork Flathead River but could also flush more out of this area with higher velocities.

MO1 operations would result in minimal changes to Flathead Lake, the lower Flathead River, and the Clark Fork River. These habitats would continue to support the macroinvertebrates described in the affected environment.

The operations of Albeni Falls Project would be similar to the No Action Alternative operations and would not result in appreciable changes to Lake Pend Oreille or the Pend Oreille River, nor to the macroinvertebrate communities in those habitats.

In the Kootenai basin, Lake Koocanusa would be held above elevation 2450 from three to thirteen more days than the No Action Alternative, which would increase the overall productivity of zooplankton and macroinvertebrates in the system. MO1 operations result in a median minimum pool elevation two feet lower than the No Action Alternative, exposing more varial zone and dewatering insect production, especially in dry years. The shallower draft through the winter compared to the No Action Alternative would lessen the effect to macroinvertebrate production.

**Region B**

The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic insects such as stonefly, caddisfly, and mayfly larvae. The operational measures that could impact macroinvertebrates under MO1 in Region B include the *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee, Winter System FRM Space, Lake Roosevelt Additional Water Supply* and *Chief Joseph Dam Project Additional Water Supply*.

MO1 operations would change river elevations at the U.S.-Canada border in the months of December and January, with much steeper drops than the No Action Alternative. MO1 levels would follow the same pattern as the No Action Alternative through April with rising elevations until July, then dropping steeply until September, when they rise again. No Action Alternative and MO1 levels would then level off about November, but in December MO1, levels would drop quickly about 4 feet where No Action Alternative levels would rise slightly and hold steady for another month and then drop at a lower rate. MO1 would result in decreased habitat and more areas becoming dewatered compared to the No Action Alternative from December through about March 1. This change in elevation of 4 feet represents the vertical feet; actual habitat dewatered would depend on the slope of the riverbanks at this elevation. As the river flows downstream closer to Lake Roosevelt, the pattern is the same but the additional drop from MO1 would result in about six feet lower elevation at river mile 720.

In Lake Roosevelt, the production, distribution and persistence of zooplankton is highly variable and sensitive to retention time of water in the reservoir, which is a function if inflows, reservoir volume, and outflows. Under MO1, the average water retention time in the reservoir would be similar to the No Action Alternative in late spring, summer, and fall. Water retention time under MO1 would be lower in December through January, but slightly higher in May in most years. In wet years is when retention time is lowest because more water is moving through the system, and MO1 would reduce retention times even further in these years by up to 10 percent in February and by 3 percent to 10 percent in the entire period of December through May. With lower retention times under MO1 in winter and spring, when retention times are already fairly low, there would be less productivity and increased entrainment of zooplankton. The elevations in Lake Roosevelt would follow the same pattern as in the river sections described above, with MO1 elevations dropping up to 6 feet lower by the end of December, rather than staying steady as in the No Action Alternative. This would result in desiccation of more aquatic macroinvertebrates and overall decreased habitat in shallow areas of the reservoir.

Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short water retention time and low productivity. Regarding aquatic insect production and desiccation, river stage at RM 594 in Rufus Woods Lake would follow the same pattern and magnitude changes as the No Action Alternative, so aquatic macroinvertebrate habitat would be the same. However, zooplankton production may decrease in response to changes in water retention time proposed under MO1.

**Region C**

The operational measures such as *Block Spill Test (Base + 120/115%)* and *Modified Dworshak Summer Draft* could impact macroinvertebrates in Region C. Low benthic production in Dworshak reservoir would be even further reduced under MO1 with a steeper drawdown starting about the third week of June. Extensive variation in water surface elevation, near-shore wave action that causes erosion and the lack of aquatic plants along the shoreline would continue to limit production. Likewise, the steeper drawdown in summer reservoir pool volume would further limit zooplankton production.

In the Clearwater River below Dworshak Dam, flow augmentation released under MO1 would begin earlier in June than the No Action Alternative, but flows in August would be reduced compared to the No Action Alternative. The pattern of high flows followed by a steep drop and then followed by high flows again would limit benthic production in the Clearwater River compared to the No Action Alternative.

The macroinvertebrate community of the lower Snake reservoirs and river would continue similar to the No Action Alternative. Warmer water temperatures could lead to a shift in zooplankton species, and these could experience more growth in the summer. Siberian prawns and opossum shrimp may continue to increase in the reservoir environments. The reservoirs would continue to provide habitat for clams, mussels, etc., as in the No Action Alternative, and crayfish would continue to find ample suitable habitat in the rock and riprap of reservoirs.

#### Region D

MO1 would result in only minor changes to flows or temperatures that could affect macroinvertebrate communities in the lower Columbia River from operational measures such as the *Block Spill Test (Base + 120/115%)* and *Increased Forebay Range Flexibility* measures. Very little benthic macroinvertebrate information is available for the lower Columbia River. Lake habitats in the impounded reaches would continue to support a low diversity of worms, benthic insects, and mollusks. In MO1, pool elevations would be about 1 foot higher in the John Day pool from late March through early June (due to bird predation measures), and then dropped in early June to the original level. During the period of March through early June, aquatic macroinvertebrates could colonize the additional benthic substrate and shallow water habitat afforded by the higher pool elevation but could be stranded or desiccated when levels drop in June. The other run of river dams would continue to be operated at stable elevations that would continue production of these aquatic macroinvertebrates.

### SUMMARY OF EFFECTS

#### Anadromous Fish

MO1 includes several structural measures intended to improve juvenile migration, including the *Additional Powerhouse Surface Passage, Upgrade to Adjustable Spillway Weirs* and *Improved Fish Passage Turbines* measures. Operationally, the *Block Spill Test (Base + 120/115%)* measure in the spring would generally increase the amount of spill at each of the lower Columbia and lower Snake projects for improved juvenile survival. The *Predator Disruption Operations* measure in the John Day reservoir would reduce juvenile predation by birds. Block spill during the spring was designed to test whether latent effects may be reduced slightly so that there could potentially be an increase in ocean survival and subsequent adult returns. Structural measures such as the *Additional Powerhouse Surface Passage* did not result in sizeable increases in juvenile survival or improvements in adult returns. Other structural measures in MO1 (e.g., *Lower Granite Trap Modifications*) would make small, incremental improvements in adult migration, but operational changes at Dworshak that were intended to improve thermal conditions for adult migrations in the Snake River actually would reduce adult migration success. Models predict that returns of salmon and steelhead would be similar to the No Action Alternative or higher. MO1 would have minor adverse effects for chum with mostly beneficial effects for lamprey, although there would be minor localized impacts. These effects are generally expected to be beneficial and negligible to minor as compared to the No Action Alternative.

**Resident Fish**

MO1 would continue many of the same key effects described in the No Action Alternative. Compared to the No Action Alternative, MO1 would have minor to moderate adverse effects in Region A due to changes in reservoir elevations and outflows reducing productivity, higher entrainment, increased varial zone effects where fish are subject to higher predation and access issues at tributary mouths, and diminished habitat in rivers downstream of reservoirs. These would affect bull trout, Kootenai River White sturgeon, and other native fish such as westslope cutthroat trout, and there would be some minor localized beneficial effects. In Region B, there would be minor to moderate adverse effects in Lake Roosevelt fish due to changes in retention time driving productivity and entrainment, habitat connectivity, stranding of kokanee and burbot eggs, habitat access for several species, and varial zone effects to redband rainbow trout. There would be negligible to minor adverse effects to white sturgeon from flow changes. In Region C, minor increases in late summer water temperatures and TDG in certain reaches such as the Snake River Basin would improve conditions for northern pikeminnow and invasive species such as smallmouth bass, adversely affecting conditions for native resident fish. Resident fish in Region D would see minor changes in flows and temperatures resulting in negligible effects to bull trout, white sturgeon, and other resident fish. 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 No Action Alternative.

**Macroinvertebrates**

The production, distribution, and persistence of macroinvertebrates are highly variable and sensitive to retention time of water in the reservoir, which is a function of inflows, reservoir volume, and outflows. In certain areas, such as at Hungry Horse and Dworshak Reservoirs, the varial zone that provides benthic insect production would be appreciably reduced due to steeper drafts in the summer and lower elevations through the winter months would result in aquatic insects becoming dewatered faster than under the No Action Alternative. In other areas, such as Lake Koocanusa, increases in timing of elevation as compared to the No Action Alternative would increase the overall productivity of zooplankton and macroinvertebrates in the system. Overall, MO1 contains both beneficial and adverse effects, which on balance are expected to be negligible to moderately adverse as compared to the No Action Alternative.

### *3.5.3.5 Multiple Objective Alternative 2*

**ANADROMOUS FISH**

**Salmon and Steelhead**

Several different ESU/DPS units of salmon and steelhead share a similar life cycle and experience similar effects from the MOs, but also have ESU/DPS specific traits that specifically drive effects differently from one another. Common effects analyses across all salmon and steelhead are discussed first, and then those ESU/DPS specific effects are displayed. Unless otherwise noted, quantitative results from COMPASS, CSS, and the Life Cycle Model (LCM) are based on a combination of hatchery and natural origin fish. This applies for both juvenile and adult results.

***Effects Common Across Salmon and Steelhead***

Summary of Key Effects

MO2 includes structural measures to improve survival of juvenile salmon and steelhead, but lower flow and spill would, generally speaking, increase travel time and the number of powerhouse encounters for juvenile outmigrants. Anadromous juveniles outmigrating in the Snake River would be transported at a higher rate than the No Action Alternative, which could result in more reaching Bonneville Dam sooner than in-river fish. Depending on ocean survival dynamics, more or fewer adults could return, and returning adults would likely have higher rates of straying and migration delays due to higher rates of transported juveniles.

Juvenile Fish Migration/Survival

There are several structural measures in MO2 that could affect juvenile salmon and steelhead. Three of these were also in MO1 and were described in detail in the Common Effects to Salmon and Steelhead under MO1 section. Juvenile modeling included adjustments in the models to account for the effects of these measures, and they are considered qualitatively where modeling is not available. These include:

- *Additional Powerhouse Surface Passage* measure at Ice Harbor, McNary, and John Day Projects: This would route additional juvenile fish away from turbine passage routes to spillway or spillway-like routes, likely decreasing travel times and increasing survival. See MO1 Common Effects for details. A key difference in MO2 however is a powerhouse surface collection facility designed to allow for smolt transportation at McNary Dam this significant design modification is different from MO1. Even with the most optimistic 30 percent passage efficiency assumption in place, the effect of these powerhouse surface passage structures on in-river survival and subsequent adult returns was minor. These structures could potentially be more effective at influencing population level dynamics at lower spill levels than those included in MO1, but even with reduced spill levels associated with MO2, there were not enough fish passing via the powerhouse to have a meaningful impact.
- The *Improved Fish Passage Turbines* measure at the John Day Project would improve juvenile survival of the juveniles that pass through this turbine route. See MO1 Common Effects for details.

MO2 also includes measures that would affect juvenile salmon and steelhead that were not in MO1, with the objective of improving power generation or complementing power with increased fish transport. They are:

- *Fewer Fish Screens* measure at Ice Harbor, McNary and John Day Projects:

Fish screens are installed to divert juvenile salmon and steelhead from turbine routes to higher survival spill routes. However, most turbines were designed to operate without screens and the addition of these screens generally reduces turbine efficiency and flexibility. Removing these screens would restore operating ranges and efficiencies while decreasing O&M costs.

Effects on fish from this structural change would be generally adverse to most fish species. We would expect an increase in the numbers of fish experiencing turbine routes at these dams, while juvenile salmon and steelhead, and most other species of fish, would experience increased mortality. By contrast, lamprey, which experience impingement on some of the screens, would likely see increases in survival as they pass the dams.

- *Increase Juvenile Fish Transportation* measure: Increasing juvenile fish transportation would affect Snake River and Columbia River fish. First, all Snake River smolts would be collected for transportation at the three Snake River collector projects, with none being bypassed back to the river. Juvenile fish would also be collected and transported from the powerhouse surface passage structure at McNary Dam. Changes in Snake River transport are incorporated into models, but because COMPASS and CSS models are not calibrated to data utilizing McNary transport facilities, model results do not reflect the effects of this measure. A rough estimate conducted by NMFS indicates that approximately an additional 9 percent of Chinook and 7 percent of steelhead would likely be transported using a powerhouse surface passage for collection. Additionally, the lower spill in MO2 would increase the number of juveniles entering juvenile bypasses and therefore available to be collected for transportation. Increasing the total fraction of natural and hatchery origin smolts transported from Lower Granite, Little Goose, and Lower Monumental dams will increase the average return rates to Bonneville Dam of the outgoing cohort of Snake River spring-run/summer-run Chinook. However, lower adult conversion rates upstream are also associated with fish that were transported as juveniles (Marsh et al. 2015; FPC memo 13-19). The increased conversion risk for adults would offset some of the benefits from the higher adult returns resulting from a higher season-wide transport rate of juveniles. As a result, transportation of natural and hatchery origin Snake River spring-run/summer-run Chinook smolts from McNary Dam may have a neutral effect on SARs (Marsh et al. 2010). Changes in transport are discussed more specifically by ESU/DPS, if applicable.

Several operational measures warrant discussion here individually, regarding effects to juvenile fish. Measures that would result in changes to spill, flows, passage routes, or temperatures were incorporated into the fish models. Others are not readily incorporated into modeling for effects analysis, or are modeled but may be difficult to separate from other factors, and so effects of these measures are discussed qualitatively.

- *Full Range Reservoir Operations* and *John Day Full Pool* measures: Increasing the operating range at the four lower Snake River dams and John Day Dam to their full operating ranges would slightly increase juvenile fish travel times and exposure to predators, but the pools would not be at full pool elevations throughout the migration season. To better understand how these elevations change throughout the season, see the Hydrology and Hydraulics modeling section of this EIS.

- *Contingency Reserves in Fish Spill* measure: Holding contingency reserves within juvenile fish passage spill is likely to have little effect on juvenile migration. Contingency reserves would be expected to be deployed at a level that would impact fish spill levels approximately once a month and are, by definition, limited to no more than 1 hour in duration. See Section 3.7, Power Generation and Transmission for more information.
- *Full Range Turbine Operations* measure: Operating turbines within and above 1 percent efficiency may or may not affect juvenile salmon and steelhead direct survival based on studies finding that peak passage survival does not coincide with observed turbine peak operating efficiency (Mathur et al. 2000; Skalski et al. 2002; Deng et al. 2007). A meta-analysis also found no association between relative turbine efficiency at a site and smolt passage survival (Skalski et al. 2002). However, Ferguson et al. (2006) reported spring-run Chinook delayed mortality resulting from operation of McNary Dam turbines outside the 1 percent range, so it is possible that operating outside 1 percent turbine efficiencies at some dams may decrease juvenile survival.
- *Zero Generation Operations* measure: Extending the zero generation operation measure would not affect juvenile salmon or steelhead because they are not migrating in the late fall/winter timeframe when this measure occurs. However, impacts to adult passage (especially for Snake River steelhead) would be anticipated due to this operation.
- The measures intended to improve conditions for lamprey in this alternative are anticipated to have a negligible effect on salmon and steelhead survival.

MO2's *Spill to Near 110% TDG* decreases the proportion of spill at each of the lower Columbia and lower Snake projects compared to the No Action Alternative. This reduced spill has the net effect of routing more juvenile salmon and steelhead towards powerhouse routes and less salmon and steelhead through spill routes. For juvenile salmon and steelhead, fish modeling was used when available to estimate the effects of these spill changes on fish.

Flow patterns in the Lower Columbia River would also change in MO2 relative to the No Action Alternative and these included median decreases in monthly average flows of 4 percent in March, and increased winter flows of 5 to 9 percent in November and December. Other months would be within 1 to 3 percent of No Action Alternative flows. In the Lower Snake River, flows would be about 18 percent higher in January and 5 percent higher in February, with lower flows in June (-3 percent) and July (-5 percent). Similar to the spill changes, fish modeling was used when available to estimate the effects of these flow changes on juvenile fish. These flow changes were caused by one or a combination of the following operational measures:

- *Slightly Deeper Draft for Hydropower*
- *Sliding Scale at Libby and Hungry Horse*
- *Modified Draft at Libby*

- *December Libby Target Elevation*
- *Update System FRM Calculation*
- *Planned Draft Rate at Grand Coulee*
- *Grand Coulee Maintenance Operations*
- *Winter System FRM Space*

MO2 is similar to the No Action Alternative from a TDG perspective but shows a small reduction in average TDG exposure. UW/CBR TDG modeling, separate from COMPASS and CSS in-river survival estimates, estimated juvenile fish median reach average exposure to TDG indices would decrease by about 2 percent relative to the No Action Alternative.

There may be increases in fish injury under MO2 with the higher number of turbine passages relative to the No Action Alternative, but reduced to some degree by installation of improved fish passage turbines at John Day Dam. However, water velocities and turbidity are not anticipated to change under MO2 relative to the No Action Alternative. There may be an overall increase in juvenile fish predation exposure under MO2 due to these factors relative to the No Action Alternative, but the magnitude is uncertain.

<u>Adult Fish Migration/Survival</u>

MO2 includes one measure, *Lower Snake Ladder Pumps*, which would install pumping systems to provide deeper, cooler water if available in the forebays to adult fish ladders at Lower Monumental and Ice Harbor Dams, intended to reduce delays in upstream adult passage. This measure is also in MO1 and is described and analyzed in more detail in the Common Effects section of MO1.

Reduction in spill throughout the lower Columbia and lower Snake projects is anticipated to reduce adult fallback rates in spring migrants that cause migratory delays (Boggs et al. 2004; Keefer et al. 2005) under MO2 and its *Spill to Near 110%* measure.

Increasing the operating range at the lower Snake River projects and at John Day Project through the *Full Range Reservoir Operations* and *John Day Full Pool* measures would have little effect on flow, and thus is not expected to affect adult migration timing or survival rates. Similarly, holding contingency reserves within juvenile fish passage spill is likely to have little effect, if any, on adult migration.

The following measures are summarized in the juvenile effects section and in detail in the Summary of Common Effects under MO1. These measures are also in MO2, and in additional to juvenile effects would result in the following effects to adult migration and survival:

- *Additional Powerhouse Surface Passage* at Ice Harbor, McNary, and John Day Dams could reduce travel time and improve downstream migration of steelhead kelts.

- Installing Improved Fish Passage (IFP) Turbines at John Day Dam could increase survival of salmon and steelhead that overshoot John Day Dam as well as steelhead kelts that pass back downstream through turbines.

As described under juvenile fish, flows would be about 4 percent lower in March and 3 to 7 percent higher in November and December in the lower Columbia River. Snake River flows would be about 18 percent higher in January and 5 percent higher in February. Any anadromous salmonids in the Columbia River or Lower Snake River at these times may be affected by these changes, as described below.

In general, there are no major water temperature changes expected as a result of MO2 but for some species in some locations, there may be localized effects. Where applicable those effects are discussed in the species-specific write-ups. Summer water temperatures in the Snake River during the most upstream migrations would not change from the No Action Alternative, nor would the percentage of days in which the ladder temperature would be more than 2 degrees Celsius warmer than the river temperature. However, Dworshak Reservoir operations would be affected such that the probability of refilling the reservoir would be lower, resulting in higher risk of not having enough water in the reservoir to provide summer cooling water.

***Upper Columbia River Salmon and Steelhead***

Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five PUD owned dams and reservoirs that also impact the survival and passage of these species. The federal agencies do not dictate generation or spill levels at the PUD projects so metrics such as powerhouse encounter rate are not directly affected but are influenced by river flow levels coming through the upper Basin. The timing and volume of flow levels affected by CRS operational decisions are reflected in model analysis. COMPASS and LCM estimates of powerhouse encounter rate and SARs include passage effects from a combination of federal and PUD dam passage (Rock Island Dam to Bonneville Dam).

<u>Upper Columbia Spring-Run Chinook Salmon</u>

*Summary of Key Effects*

The structural and operational measures in MO2 overall would reduce juvenile survival from McNary Dam pool to Bonneville Dam with longer travel times and increased powerhouse encounters. Adult migration success may be enhanced by lower spill, but with lower juvenile survival, overall abundance of returning adults to spawning grounds would be about 3 percent lower than the No Action Alternative. Some upper Columbia Chinook salmon would be transported from McNary Dam under this operation, but the effects could not be quantitatively assessed.

*Juvenile Fish Migration/Survival*

This ESU migrates through the Columbia River downstream past the four lower CRS projects as well as up to five non-federal dams. Structural and operational measures described in the Common Effects section that describe changes from the No Action Alternative at McNary, John Day, The Dalles, and Bonneville Projects would apply to these fish. Additional surface passage and upgrading spillway weirs at McNary and John Day Dams may improve juvenile survival but removing fish screens at both dams would result in more juvenile fish going through turbines,, though improved turbines could offset this effect with increased survival of turbine route fish. COMPASS modeling indicates MO2 would decrease juvenile survival about 1.3 percent, increase travel time 7 percent and increase the number of powerhouse routes encountered by juvenile fish by 11 percent. TDG exposure would generally be lower than the No Action Alternative for these fish (Table 3-79). Overall, juveniles would likely encounter increased predation risk in MO2, compared to the No Action Alternative, with longer travel times and increased powerhouse encounters between McNary and Bonneville dams.

**Table 3-79. Multiple Objective Alternative 2 Juvenile Model Metrics for Upper Columbia River 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% |

*Adult Fish Migration/Survival*

There are no structural measures in MO2 to benefit upstream migration of adult upper Columbia River spring-run Chinook salmon. Adult exposure to TDG would be lower than the No Action Alternative, and lower spill levels would generally reduce migration delays and fallback.

With decreased juvenile survival and slower juvenile travel time, the SARs and the resulting abundance of returning adults would be expected to decrease under MO2 compared to the No Action Alternative. NWFSC LCM modeling predicted MO2 would result in a 3 percent decrease in median abundance, based on modeling of the Wenatchee population. This prediction assumes no change in potential latent mortality of juvenile fish compared to the No Action Alternative. Estimates of potential increases or decreases in ocean mortality were not computed for MO2. Table 3-80 displays the model results for the Wenatchee population:

**Table 3-80. Multiple Objective Alternative 2 adult model metrics for Upper Columbia River 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% |

1/ SAR estimates include passage effects from three non-federal dams.
2/ Abundance estimates do not assume any latent effects from Columbia River System passage.

Upper Columbia River Steelhead

*Summary of Key Effects*

COMPASS modeling estimates that MO2 is expected to result in a 4 percent decrease in average juvenile survival for upper Columbia steelhead between McNary and Bonneville dams; no change in average juvenile travel time is expected, but a six percent increase in the number of powerhouse passage events compared to the No Action Alternative would occur.

*Juvenile Fish Migration/Survival*

Juveniles from this DPS migrate downstream past the four lower CRS projects and through up to five PUD owned dams in the mid-Columbia. Operations at upstream reservoirs that affect seasonal flow patterns downstream influence travel time and survival at the PUD owned projects. Structural and operational measures described in the Common Effects section, including the *Additional Powerhouse Surface Passage* measure at McNary and John Day, and the *Upgrade to Adjustable Spillway Weirs* measure at McNary would improve spill passage effectiveness, but removing fish screens at McNary Dam and John Day Dam would increase turbine routes and increase mortality of juveniles. Juveniles collected at the powerhouse surface bypass at McNary would be transported within season. COMPASS modeling predicts juvenile survival under MO2 would decrease 2.4 percent, travel time would be the same as the No Action Alternative, and powerhouse encounters would increase. TDG exposure would be less than the No Action Alternative. MO2 Table 3-81 displays the juvenile metrics for upper Columbia River steelhead. Overall, juveniles could encounter increased predation risk in MO2, compared to the No Action Alternative, with increased powerhouse encounters between McNary and Bonneville dams.

**Table 3-81. Multiple Objective Alternative 2 Juvenile Model Metrics for Upper Columbia River 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% |

MO2 includes a measure to increase transportation, including transport from McNary Dam.

*Adult Fish Migration/Survival*

As described in the Common Effects, upstream migration of adult steelhead would be improved by lower spill and lower TDG. The structural measures designed to improve juvenile fish survival, including additional surface passage, spillway weir upgrades, and improved fish passage turbines, would increase survival of steelhead kelts. Life cycle models were not available for steelhead, but overall abundance would likely be lower than the No Action Alternative due to decreased survival of juveniles.

<u>Upper Columbia River Coho Salmon</u>

See upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile upper Columbia coho salmon and upper Columbia fall Chinook salmon analysis as a surrogate for adult upper Columbia coho salmon.

*Summary of Key Effects*

The primary challenges for upper Columbia River coho salmon are the conditions they encounter during upstream and downstream migrations. Juvenile Upper Columbia coho salmon would survive similar to juvenile Upper Columbia spring-run Chinook salmon; minor decreases are expected due to operation and structural changes that would result in slower travel time and more powerhouse encounters. Upper Columbia Fall Chinook are the more appropriate surrogate for adult Upper Columbia coho salmon and based on surrogate analysis, minor decreases in adult returns would be expected.

*Juvenile Fish Migration/Survival*

Juvenile survival of upper Columbia River coho salmon is estimated using COMPASS juvenile modeling results for upper Columbia River spring-run Chinook salmon as a surrogate. Structural and operational measures contributing to changes in MO2 include increased surface passage structures, upgrading to adjustable spillway weirs, installation of improved fish passage turbines, and removal of fish screens at McNary Dam. These are discussed in the Common Effects section.

Overall, juveniles would likely encounter increased predation risk in MO2, compared to the No Action Alternative, with longer travel times and increased powerhouse encounters between McNary and Bonneville dams.

*Adult Fish Migration/Survival*

Measures described in the Common Effects section that affect the four lower Columbia River projects would apply to upstream migration and survival of adult upper Columbia River coho salmon. Adult migration conditions would be similar to upper Columbia River fall-run Chinook salmon, which were analyzed in workshops using water quality and hydrology information. MO2 water quality modeling indicated no change in the frequency of water temperatures exceeding 20°C, nor any change in ladder temperature differentials in the lower Columbia relative to the No Action Alternative. The late run of upper Columbia River coho salmon migrates upstream in November and December, when flows would increase an average of 9 percent in the Columbia River below McNary Dam.

See upper Columbia Fall Chinook salmon analysis as a surrogate for adult upper Columbia coho salmon.

<u>Upper Columbia River Sockeye Salmon</u>

Refer to the upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia River sockeye salmon.

*Summary of Key Effects*

Juvenile sockeye salmon would experience lower survival during outmigration in the river than under the No Action Alternative. The most important change for Columbia River sockeye from MO2 is the potential for transportation of juveniles, which can improve survival but may have the consequence of higher rates of straying when they return as adults.

*Juvenile Migration/Survival*

Reduced spill operations in MO2 is expected to result in minor increases to juvenile upper Columbia River sockeye migration times compare to the No Action Alternative. River flows during the driest 25 percent of years would be slightly lower, but there would not be a substantial difference from the No Action Alternative. Juveniles would encounter more powerhouses, but this may partly be offset by increased survival through expected turbine improvements. TDG exposure would be lower than the No Action Alternative. Overall juveniles would likely encounter increased predation risk and reduced survival, as indicated by a minor decrease in survival indicated by the COMPASS modeling of the surrogate species, upper Columbia River spring-run Chinook salmon.

In MO2, there is potential for transport of juvenile fish starting at McNary Dam, which would likely lead to an increase in the adverse effects of fallback and straying by the adult fish that were transported as juveniles.

Overall, juveniles would likely encounter increased predation risk in MO2, compared to the No Action Alternative, with longer travel times and increased powerhouse encounters between McNary and Bonneville dams.

*Adult Migration/Survival*

MO2 would have a minor increase in the percentage of days over 18°C as measured at McNary and Chief Joseph Dams. For sockeye salmon, the inflection point for the survival/temperature relationship is 18°C. This relationship is not as strong for upper Columbia sockeye because they typically migrate 5 to 7 days earlier than Snake River sockeye. The water temperature at Chief Joseph Dam influences sockeye that use the nearby tributary of Okanogan River. Okanogan sockeye arrive at the confluence of the Okanogan River with the Columbia River when water temperatures are warmer than 21°C, and then hold in the mainstem Columbia River. From around July 1 until the end of August, sockeye hold in the mainstem of the Columbia River until they get a temperature break in the Okanagan River and are then able to move upstream toward their spawning areas. Earlier runs of fish are more successful. The cumulative stress of moving up through warm water in the Columbia River and then experiencing warm water at the confluence of the Okanogan River where they hold could increase the cumulative stress, which may decrease adult fish survival. The minor increase in days over the 18°C under MO2 would have a corresponding increase in stress from elevated water temperatures.

<u>Upper Columbia River Summer/Fall-Run Chinook Salmon</u>

*Summary of Key Effects*

See Upper Columbia River spring-run Chinook analysis as a surrogate for upper Columbia River Summer/Fall Run Chinook Salmon.

No change is anticipated in McNary and John Day reservoir plankton communities or shoreline habitats under MO2, relative to the No Action Alternative. Likewise, juvenile rearing habitat below Bonneville Dam is not expected to change relative to the No Action Alternative. Overall, no changes are anticipated for juvenile upper Columbia summer/fall-run Chinook.

*Juvenile Fish Migration/Survival*

Upper Columbia River Summer/Fall Run Chinook Salmon would likely experience lower juvenile survival, with small increases in travel time and powerhouse encounters. Lower TDG would benefit both juvenile and adult fish, and adult migration would be increased with lower fallback and delays due to spill. Overall abundance under MO2 would likely be less than No Action Alternative due to juvenile effects.

*Adult Fish Migration/Survival*

The number of days water temperatures in the McNary tailrace exceed 20°C and the number of days that adult ladder temperature differentials exceed 2°C would not change relative to the No Action Alternative. No changes in migration delay, fallback, or susceptibility to disease are anticipated due to overall warmer mainstem water temperatures at the lower Columbia dams (Caudill et al. 2013).

Specific to Okanogan upper Columbia summer/fall-run Chinook, there is no change in number of days the mainstem would be 20°C or higher at the confluence of the Okanogan, relative to the No Action Alternative as opposed to the 18°C threshold discussed above for sockeye salmon. This means that there would be no change anticipated in the ability of the Okanogan fish to hold in the mainstem until temperatures in the Okanogan are cool enough that adults can move up from the mainstem without having to migrate through water temperatures typically considered lethal for salmon and steelhead (Ashbrook et al. 2009).

The frequency of meeting the Vernita Bar Agreement to protect the prolific fall-run Chinook spawning in and around the Hanford Reach of the Columbia River in Washington is not expected to change under any MOs relative to the No Action Alternative. Other operational changes under MOs are likewise not anticipated to affect upper Columbia River summer/fall-run Chinook spawning from the tailrace of Chief Joseph Dam to Bonneville Dam in terms of changes in flows, water temperatures, or TDG generated under the MOs.

***Middle Columbia River Salmon and Steelhead***

Middle Columbia River Spring-Run Chinook Salmon

See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River Spring-Run Chinook Salmon.

*Summary of Key Effects*

Middle Columbia River spring-run Chinook salmon would likely experience lower juvenile survival, with small increases in travel time and powerhouse encounters. Lower TDG would benefit both juvenile and adult fish, and adult migration would be increased with lower fallback and delays due to spill. Overall abundance under MO2 would likely be less than No Action Alternative due to juvenile effects.

*Juvenile Fish Migration/Survival*

See upper Columbia River spring-run Chinook salmon analysis as a surrogate for juvenile middle Columbia River spring-run Chinook salmon. Under MO2, surrogate analysis results predict CRS operational changes may result in lower survival, higher travel times, and increased powerhouse passage events on juvenile middle Columbia River Chinook.

Measures described in the Common Effects section that refer to the lower four projects in the Columbia River would apply to middle Columbia River spring-run Chinook salmon. Middle Columbia River juvenile salmon would typically experience higher absolute survival than upper Columbia River spring-run Chinook salmon because they don’t experience the higher mortality associated with the Columbia River from Chief Joseph Dam downstream to McNary Dam, but the percent change in juvenile survival would be similar because they experience the same CRS projects between McNary and Bonneville dams.

*Adult Fish Migration/Survival*

See upper Columbia River spring-run Chinook salmon analysis as a surrogate for adult migration and survival of middle Columbia River spring-run Chinook salmon. As described in Common Effects, lower spill may increase the upstream migration success of middle Columbia River spring-run Chinook salmon by reducing fallback and delays. Under MO2, decreased juvenile survival would likely result in reduced abundance of adult returns to the spawning grounds.

Middle Columbia River Steelhead

Refer to Upper Columbia River steelhead analysis as a surrogate for Middle Columbia River steelhead.

*Summary of Key Effects*

Juvenile middle Columbia River steelhead survival would be improved by structural measures but decreased overall by operations. The portion of the middle Columbia River steelhead that do not pass McNary or John Day dams (e.g., Deschutes MPG) would have better survival than the ones that encounter all four Columbia River dams, including two of the dams considered with fish screens removed. Adult migration conditions and kelt survival would increase but overall abundance may be lower.

*Juvenile Fish Migration/Survival*

Populations of middle Columbia River steelhead distributed between the Deschutes and Walla Walla Rivers pass two to four dams in the lower Columbia on their downstream outmigration to the ocean. Upper Columbia River steelhead modeling results were used as a surrogate for middle Columbia River steelhead (refer to Section 3.5.3.4). Under MO2, modeling results predicted that survival from McNary to Bonneville would experience minor decreases, although populations that only pass two dams would likely see a smaller decrease, when compared to No Action Alternative, due to the removal of fish screens at McNary and John Day which would not affect those populations with natal streams below John Day Dam. Increased powerhouse passage events were also indicated by the model and would reduce juvenile survival. Operational and structural measures contributing to this decrease are discussed in Common Effects section.

*Adult Fish Migration/Survival*

Under MO2, lower spill would increase adult migration success compared to the No Action Alternative. Structural measures designed for juvenile fish passage improvements such as increased surface passage would also improve survival of kelts. However, the decrease in juvenile survival metrics may result in fewer returning adults. Refer to upper Columbia River steelhead analysis as a surrogate for middle Columbia River steelhead.

#### ***Snake River Salmon and Steelhead***

Snake River Spring/Summer-Run Chinook Salmon

*Summary of Key Effects*

Juvenile survival of in-river migrating fish would be lower than the No Action Alternative, though the models disagree somewhat on the magnitude of changes. MO2 would increase transportation of juvenile fish. The increased survival and faster travel time for this transported component of juveniles would help offset survival decreases of in-river fish when considered in the life cycle because more smolts would arrive at Bonneville Dam. The predictions of ocean survival and subsequent returns to the Columbia River system varies by model. The NWFSC LCM predicts slightly higher returns because more smolts would arrive at Bonneville Dam sooner, thus a higher number would survive the ocean phase and return. CSS predicts the benefit of transported juveniles would increase the number of smolts arriving at Bonneville, but lower ocean survival, likely due to increased latent mortality from the system experience. The CSS model ultimately predicts far fewer fish returning to spawning grounds compared to the No Action Alternative.

*Juvenile Fish Migration/Survival*

This ESU migrates through the Snake and Columbia Rivers downstream past the eight CRS projects, four on the Snake River, and four on the lower Columbia River. Structural and operational measures described in the Common Effects section that describe changes at all of these dams would apply to these fish. This includes structural measures designed to reduce the proportion of smolts passing through powerhouse routes and increase survival of smolts that do pass through the turbines, as well as measures to improve power generation that may increase smolt passage through these routes. Transport of smolts from the lower Snake River Projects would increase, but the effects of transportation from McNary Dam were not qualitatively evaluated by either the CSS or COMPASS models. See the Common Effects section for details.

For Snake River spring-run/summer-run Chinook salmon, both models indicated a decrease in juvenile survival and increased travel time and more powerhouse passages, but vary on the magnitude of change. TDG modeling indicates lower reach average exposure for juveniles. Table 3-82 displays the juvenile metrics for MO2 predicted by each of the models.

**Table 3-82. Juvenile Model Metrics for Snake River Spring/Summer-Run Chinook Salmon 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% |

As described in Common Effects, the measures to increase juvenile fish transportation and decrease spill would result in more juveniles transported than the No Action Alternative. COMPASS, which uses only wild fish to assess transport, indicates the percentage of Snake River spring Chinook transported would increase from 38.5 percent in the No Action Alternative to 47.4 percent in MO2. CSS includes hatchery and wild fish both in the model and predicts 19.2 percent of all smolts would be transported under the No Action Alternative but increase to 33.8 percent under the No Action Alternative. CSS also predicts the benefit of being transported (the Transport: In-River Benefit Ratio) would increase from below one under the No Action Alternative to 1.18 under MO2. This means that, on average throughout the transport season, under the No Action Alternative fish left in-river would have overall better survival odds, but under MO2, it would be more beneficial to be transported. Neither model accounts for changes in proportion of the run that would be transported nor the additional effects if McNary Dam was used as an additional collection point. Further discussion of effects of transport later in the life cycle is in the following section on adult fish migration and survival.

*Adult Fish Migration/Survival*

The structural measure in MO2 to install pumping systems at Ice Harbor and Lower Monumental would benefit adult Snake River spring-run/summer-run Chinook salmon passage upstream if cooler water is available in the forebays. The reduced spill in MO2 may add benefit for adult migration with lower fallback rates, since fallback for this ESU has been associated with higher flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). The fish that fell back were significantly less likely to reach their spawning areas compared to fish that never fell back.

The NWFSC LCM results indicated a very small increase in overall SARs (+0.02 percent) and that there would be an average of 11 percent increase in median adult abundances across all the Snake River spring-run/summer-run Chinook populations modeled relative to the No Action Alternative. CSS model results, however, indicate reduced SARs (-0.6 percent) and large decreases in abundances (-43 percent average, with a range among populations in the Grande Ronde/Imnaha major population group of -38 percent to -55 percent). These decreases are largely driven by a large decrease in ocean survival (2.8 percent in MO2, compared to 3.6 percent in the No Action Alternative). See Table 3-83 for a summary of model outputs.

**Table 3-83. Multiple Objective Alternative 2 Adult Model Metrics for Snake River 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% |

[1] CSS provided results for six populations in the Grande Ronde/Imnaha Major Population Group. The absolute values represent those populations only; the percent change is considered indicative of the Snake River ESU for the purpose of comparing between MOs.

The differences in model assumptions and the resulting predictions discussed in the methods section (3.5.3.1) are applicable in understanding MO2 effects on Snake River spring/summer-run Chinook salmon. To calculate the smolt to adult return rate for the population, the NMFS LCM uses input metrics from COMPASS results such as juvenile survival and travel timing. The model continues to estimate a population's survival once the individuals pass Bonneville Dam, enter the ocean, rear and grow for several years, and then return as adults to Bonneville Dam. The model then adds an adult migration module that starts with the number of adults reaching Bonneville dam and computes expected survival on migration upstream to spawning grounds in the upper Snake River basin. It is important to remember that the juvenile survival indicated in the COMPASS metrics in the juvenile survival table applies to in-river travelling smolts only. Based on previous research, transported smolts are estimated to have a survival rate of 98 percent from Lower Granite to Bonneville, compared around 50 percent for in-river smolts. In MO2, the higher proportion of transported fish results in more smolts experiencing the higher transported survival rate.

Similarly, CSS also indicates a benefit to transported fish in this alternative when comparing the SARs between the two groups, likely due to decreased survival of in-river migrating fish in MO2.

One of the drivers of the LCM ocean survival module is the arrival timing of smolts to the ocean; because more smolts are transported, and transported fish have better initial survival rates and much faster arrival timing than in-river fish. The results from the model are increased abundance of adults arriving back to Bonneville Dam, as indicated by an increase in SAR. Timing is also important; generally speaking, fish transported later in the season experience better SARs than in-river fish. Earlier in the season, there is generally a higher benefit to in-river travel. Seasonal changes can be driven by reduced in-river survival due to increased predation and thermal stress.

The NWFSC LCM indicates a higher abundance of fish returning to spawning grounds because higher transportation rates increase SARs, especially later in the season, and those adults then experience higher migration success from Bonneville to spawning grounds. It is important to note, however, that the higher rate of transported smolts would result in more adults straying to different populations than their origin.

One major difference between the models is in the ocean survival module. CSS incorporates data indicating latent mortality that is dependent on the hydrosystem experience of each smolt. For MO2, ocean survival was predicted to decrease from 3.6 percent under the No Action Alternative to 2.8 percent. Latent mortality associated with powerhouse passage rates and increased travel time in the CSS model are the likely drivers in the different SAR predictions between the two models.

<u>Snake River Steelhead</u>

*Summary of Key Effects*

Juvenile survival of in-river migrating fish would be lower than the No Action Alternative; both models indicate decreases, though magnitude varies between the models. MO2 would increase transportation of juvenile fish; the increased survival and faster travel time for this transported component of juveniles would help offset survival decreases of in-river fish when considered in the life cycle. More smolts would arrive at Bonneville Dam. CSS predicts the benefit of transported juveniles would be higher but predicts lower SARs. Neither model was able to predict abundance. Adults would likely express higher rates of straying.

*Juvenile Fish Migration/Survival*

This DPS migrates through the Snake and Columbia Rivers downstream past eight CRS projects, four on the Snake River, and four on the lower Columbia River. Structural and operational measures described in the Common Effects section that describe changes at these dams would apply to these fish. This includes structural measures designed to reduce the proportion of smolts passing through powerhouse routes and increase survival of smolts that do pass through the turbines, as well as measures to improve power generation that may increase smolt passage through these routes at some dams. Transport of smolts from the lower Snake River Projects would be increased but the effects of transportation from McNary Dam were not evaluated by either the CSS or the COMPASS models. See the Common Effects section for details. For Snake River steelhead, both models indicated a decrease in juvenile survival, increased travel time and more powerhouse passages, but vary somewhat on the magnitude of change. TDG modeling indicates lower reach average exposure for juveniles, and a reduction in juvenile mortality associated with TDG exposure. Table 3-84 displays a summary of the juvenile metrics:

**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% |

As described in Common Effects, the measure to increase juvenile fish transportation and decreased spill would result in more juveniles transported than the No Action Alternative. COMPASS, considering only wild fish in the equation, indicates the percentage transported would increase from about 40 percent to about 48 percent. CSS did not provide an estimate of proportion transported, but predicts the Transport: In-River Benefit Ratio would increase from 1.41 under the No Action Alternative to 2.23 under MO2. Steelhead experience higher benefits from transportation than Snake River spring-run/summer-run Chinook salmon.

On average throughout the transport season, under the No Action Alternative transported fish would have long-term survival advantages over in-river fish, and under MO2 the difference in this metric would be larger (i.e., higher survival benefits for transported fish). Neither of the models account for changes in the proportion of the run that would be transported, nor the additional effects if McNary Dam was used as an additional collection point. Further discussion of effects from transport later in the life cycle is in the following section on adult fish migration and survival.

*Adult Fish Migration/Survival*

CSS cohort modeling estimated smolt to adult return (SAR) estimates from Lower Granite to Bonneville would decrease from 1.8 percent under the No Action Alternative to 1.2 percent in MO2. Lower SARs would indicate that total abundance of adult steelhead would decrease as well. No other life cycle modeling was available.

Qualitatively speaking, the benefit of transport would be higher (i.e., resulting in higher SARs for transported fish) in MO2, and more fish would be transported as juveniles, which could increase the ocean survival of steelhead, but it is unknown if the benefit of transport would sufficiently overcome the reduction in in-river survival to increase or decrease adult returns. Conversely, CSS modeling predicted decreased ocean survival (2.5 percent compared to 2.9 percent in the No Action Alternative) that would result in lower abundances of adult returns. Higher proportions of fish that were transported as juveniles may increase the rate of straying in adult returns. Keefer and Caudill (2012) reported a 2 to 7 percent stray rate for non-transported steelhead vs. 7 to 9 percent among transported fish.

Transportation has been shown to provide a benefit to steelhead. Full life cycle modelling from COMPASS was not available, however, modelled data shows that MO2 would increase transportation rates by 8 percent and result in increased return rates at Lower Granite Dam, in the absence of latent mortality effects predicted in the CSS model.

Lower spill levels during April and May would likely result in lower survival rates for adult steelhead falling back through dams and kelts migrating downstream, as more adults would use powerhouse passage routes that are generally associated with lower survival rates (Normandeau et al. 2014; Ham et al. 2012).

<u>Snake River Coho Salmon</u>

See Snake River spring/summer-run Chinook salmon as a surrogate for juvenile Snake River coho salmon and Snake River fall-run Chinook as a surrogate for adult Snake River coho salmon.

*Summary of Key Effects*

Juvenile Snake River coho salmon survival would decrease in MO2, but the models predict different magnitudes of decrease for the surrogate species (Snake River spring/summer-run Chinook salmon). Juveniles would experience more powerhouses and have slower migration times, and more juveniles would be transported than under the No Action Alternative. These transported juveniles would experience higher survival than in-river fish.

*Juvenile Fish Migration/Survival*

Refer to MO2 Snake River juvenile spring Chinook results as a surrogate for Snake River Coho Salmon.

*Adult Fish Migration/Survival*

Abundance of Snake River coho salmon was not modeled, but some inferences can be made from life cycle modeling of Snake River spring/summer-run Chinook salmon. This ESU was used as a surrogate for Snake River coho salmon juvenile metrics, indicating more coho salmon would be destined for transport than in the No Action Alternative. The net effect of these factors under MO2 on coho salmon returns is uncertain. If greater survival of transported fish was offset by decreased juvenile survival, there could be minor net increase of adults. If latent effects of powerhouse encounters decrease ocean survival, there would be fewer adults.

<u>Snake River Sockeye Salmon</u>

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake River sockeye salmon.

*Summary of Key Effects*

The key effects of MO2 are the slightly slower migration time that puts juvenile sockeye at greater risk of predation. Although the proposal for transporting juveniles might improve survival for that life stage, this action is likely to cause a greater rate of fallback and straying of adults on their upstream migration compared to the No Action Alternative. Overall abundance of returning fish would depend on how increased transport, later arrival timing, and any latent effects from increased powerhouse encounters affect ocean survival.

*Juvenile Migration/Survival*

MO2 is expected to result in a slightly slower migration time for juvenile sockeye (approximately one day) based on modeling results for surrogate species juvenile Snake River spring-run Chinook because they migrate downstream at approximately the same time of year. Travel rates for juvenile sockeye are typically faster than yearling Chinook and therefore the use of this surrogate may provide a conservative estimate. See upper Columbia River sockeye salmon (Section 3.5.3.2) for additional travel time information compared to yearling Chinook salmon that migrate through the middle Columbia River. Spill rates under MO2 may contribute to a slower travel time, and the proportion of fish going through the powerhouse would be higher.

It is assumed that slower travel times result in lower survival rates due to greater swimming effort and longer duration of exposure to predators. Predation by fish in reservoirs would continue to occur at the same rate as in the No Action Alternative based on water temperature, which is used as an index to estimate predator activity. However, based on the slightly slower travel time as described above, juvenile sockeye salmon would have a slightly longer exposure time for risk of predation in MO2. Among bird predators, their nesting population is expected to be the same as in the No Action Alternative, but again the slower travel time would put the juvenile sockeye at greater risk of exposure.

*Adult Migration/Survival*

In MO2, the surrogate species for Snake River sockeye salmon, Snake River spring/summer-run Chinook salmon, would have approximately a 10 percent increased rate of transportation as juveniles compared to the No Action Alternative. This substantial increase in transport would likely lead to a proportional increase in the adverse effects for the adult fish that were transported as juveniles. These adverse effects would include impaired ability to find their birth streams (i.e., homing ability), migration delay, increased fallback, and straying. This impaired homing ability may contribute to higher un-intentional catch during other fisheries in the lower Columbia River, and can be lethal during warm water years (NMFS 2015).

The summer water temperatures in the river during the upstream migration would not change from the No Action Alternative, nor would the percentage of days in which the ladder temperature would be more than 2 degrees Celsius warmer than the river temperature. However, Dworshak Reservoir operations would be affected such that the probability of refilling the reservoir would be lower, resulting in higher risk of not having enough water in the reservoir to provide summer cooling water. In MO2, fewer days per year would have TDG over 120 and 125 percent at all projects. This change is substantial enough that MO2 would have fewer adverse effects from TDG on Snake River sockeye compared to the No Action Alternative. The other important water quality parameters of suspended sediment and DO would have no change compared to the No Action Alternative.

Snake River Fall-Run Chinook Salmon

*Summary of Key Effects*

Although the proposal for transporting juveniles might improve survival for that life stage, this action is likely to cause a greater rate of fallback and straying as adults on their upstream migration compared to the No Action Alternative.

*Larval Development/Juvenile Rearing*

None of the measures of MO2 would change the substrate sizes or distribution in the spawning areas or expand suitable spawning areas; therefore, this alternative is expected to have the same larval development and juvenile rearing habitat conditions as the No Action Alternative. The same is true for river depths in the spawning areas; no change is anticipated for eggs incubating in the gravel. MO2 would not have a measurable difference compared to the No Action Alternative for juvenile Chinook rearing in reservoirs; therefore, their visual cover from predation would not change.

*Juvenile Migration/Survival*

None of the measures in MO2 would affect turbidity during juvenile Chinook outmigration months of May through July. The combination of structural measures intended to improve juvenile survival and operational and structural measures that would decrease survival would likely result in a net decrease in juvenile survival. See the Common Effects section of MO2 for a description of these measures.

*Adult Migration/Survival*

Adult straying rate is expected to increase in MO2 due to the operational measure to maximize transport. This would reduce the total number of adult fall-run Chinook returning to the Snake River because of the expected increase in rate of straying and fallback. Depending on the overall transport to in-river benefit ratio, this may cause a decrease in adult returns to spawning areas of the Snake River basin.

River water temperatures during the upstream migration period are expected to be the same as in the No Action Alternative. The same is true for the temperature difference between the river and the fish ladders. However, the probability of Dworshak filling would be lower in MO2, resulting in more years where the volume of water required for cooling the Snake River with Dworshak water would not be sufficient. This would affect the early part of the Snake River fall Chinook salmon run. There would be no change to sediment concentrations or DO levels from any measures in MO2 during the adult migration period.

***Lower Columbia River Salmon and Steelhead***

Lower Columbia River Chinook Salmon

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower Columbia River Chinook salmon.

*Summary of Key Effects*

Juvenile survival and travel time would be similar to the No Action Alternative, with slight increases in modeled metric of surrogate species (Snake River spring/summer-run Chinook salmon), but slight decreases in qualitative analysis. Adult migration and survival would be expected to be higher with lower flows, lower spill, and lower TDG.

Results (and change from the No Action Alternative) for metrics for Lower Columbia River Chinook salmon:

- Negligible increase in juvenile project survival at Bonneville Reservoir and Dam (see surrogate species Snake River spring-run/summer-run Chinook) = (+0.5 percent)
- Bonneville outflows, April-June = (-1 percent to -2 percent)
- Bonneville outflows, August-September = (August: -1 percent to -2 percent, September: +1 percent to +2 percent)
- Spill, Bonneville = April (-42 to -28kcfs), May (-40kcfs), August (-87kcfs)
- Temperature, The Dalles, days exceeding state standard = 71 days (0 days)
- Temperature, Bonneville, days exceeding state standard = 57 days (-1 day)
- TDG, The Dalles, days exceeding state standard = 11 days (-22 days)
- TDG, Bonneville, days exceeding state standard = 46 days (-18 days)

*Juvenile Fish Migration/Survival*

Five of the 32 populations of Lower Columbia River Chinook salmon pass Bonneville Dam on their downstream outmigration to the ocean. Modeling was not available for this ESU so juvenile survival at Bonneville Dam of Snake River spring-run/summer-run Chinook salmon was used as a surrogate of juvenile survival for the proportion that pass this project. COMPASS modeling under MO2 predicted similar juvenile survival through the Bonneville Dam compared to No Action Alternative, which is consistent with the expectation that lower spill at Bonneville Dam could result in slightly higher survival.

Outflows can influence juvenile outmigration if changes in flows are enough to noticeably affect travel time, and therefore survival. Hydrology modeling predicts spring-run and late-fall-run fish would experience outflows about 1 to 2 percent lower than the No Action Alternative. Fall-run fish outmigrate in late summer and may see flows 1 to 2 percent lower than the No Action Alternative except in September when flows would be 1 to 2 percent higher than the No Action

Alternative. Changes of this magnitude would likely be imperceptible on effects to juvenile outmigration. Likewise, water quality modeling indicated there would not be a perceptible change in temperature in the lower river with MO2 operations, and TDG would be lower than under the No Action Alternative.

*Adult Fish Migration/Survival*

MO2 does not include the structural measure to modify the upper ladder serpentine sections at Bonneville Dam seen in other MOs. Lower spill in MO2 would decrease fallback rates and lower TDG could reduce impacts on adults. Hydrology and water quality modeling predicts flows and temperatures that could affect lower Columbia River Chinook salmon adult migration and survival would be similar to the No Action Alternative.

<u>Lower Columbia River Steelhead</u>

Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

*Summary of Key Effects*

Juvenile survival would be similar to or slightly lower than the No Action Alternative, with similar modeled dam survival but slightly reduced flows in March and slower travel time. Adult migration of a portion of the winter run could be decreased slightly with higher winter flows, and survival of kelts would be lower with reduced spill, although lower TDG may increase survival.

MO2 results (and change from the No Action Alternative) for metrics for Lower Columbia River steelhead:

- Negligible decrease in juvenile project survival, Bonneville Reservoir and Dam (see Snake River steelhead [used as a surrogate]) = (-0.1 percent)
- Bonneville outflows, March = (-4 percent), April-June = (-1 percent to -2 percent)
- Bonneville outflows, November-December = (+3 to +7 percent), otherwise (+/- 0 to 2 percent)
- Spill, Bonneville = April through June = (-28kcfs to -39kcfs), August (-87kcfs)
- Temperature, The Dalles, days exceeding state standard = 71 days (0 days)
- Temperature, Bonneville, days exceeding state standard = 57 days (-1 day)
- TDG, The Dalles, days exceeding state standard = 11 days (-22 days)
- TDG, Bonneville, days exceeding state standard = 46 days (-18 days)

*Juvenile Fish Migration/Survival*

Four of the 23 populations of Lower Columbia River steelhead pass Bonneville Dam on their downstream outmigration to the ocean. Modeling was not available for Lower Columbia River steelhead, so juvenile survival at Snake River steelhead was used as a surrogate of juvenile survival through the Bonneville project (pool and dam) for this portion of the DPS. COMPASS modeling predicts a negligible decrease or similar juvenile survival under MO2 compared tothe No Action Alternative. Four percent lower outflows in March and generally lower spill may reduce juvenile migration success; the remainder of the outmigration period would be similar (-1 percent to -2 percent) to the No Action Alternative. Temperatures would be similar to the No Action Alternative, and TDG would be lower with reduced spill.

*Adult Fish Migration/Survival*

MO2 does not include structural measures for adult passage improvements for Lower Columbia River steelhead. Under MO2, lower spill through spring and summer and spill reduction in August would lower survival rates for adult kelts, but generally reduce adult fallback and delay. A higher proportion of kelts moving downstream would pass Bonneville Dam via turbines, which have lower survival rates than spill. Winter run steelhead migrating in December would experience flows about 7 percent higher than the No Action Alternative. Otherwise, adult passage conditions due to flows would be similar to the No Action Alternative. Temperatures would be similar to the No Action Alternative, and adult fish would generally experience lower TDG, with 18 to 22 more days under the state water quality standard than the No Action Alternative.

<u>Lower Columbia River Coho Salmon</u>

See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult Lower Columbia River coho salmon.

*Summary of Key Effects*

Lower Columbia River coho salmon juvenile survival and adult migration factors would be similar or slightly better than the No Action Alternative based on surrogate information. Juvenile survival would have negligible to minor decreases. TDG exposure would be lower, and temperatures would be cooler around Bonneville Dam.

*Juvenile Fish Migration/Survival*

Juvenile survival of Lower Columbia River coho salmon passing Bonneville Dam, based upon project survival of Snake River spring/summer-run Chinook salmon as a surrogate, would have negligible to minor decreases in MO2, relative to No Action Alternative. Generally speaking, lower spill at Bonneville Dam results in higher survival through the dam. Refer to Snake River spring-run Chinook for surrogate information (Section 3.5.3.5).

*Adult Fish Migration/Survival*

Lower Columbia River coho salmon adults are similar in upstream migration characteristics to Snake River fall-run Chinook salmon and were used as a surrogate; Snake River fall-run Chinook salmon were analyzed in workshops using modeled water quality and hydrology data. The results of modeled water quality and hydrology data depicted that water temperatures around Bonneville Dam may be slightly cooler under MO2 compared to the No Action Alternative and could benefit upstream migrating Lower Columbia River coho salmon. MO2 operational changes would not change the number of days when lower Columbia River water temperatures in reservoirs would exceed 20°C and/or fish ladder temperature differentials exceed 2°C, cause adult salmon to stop or delay migration, increase fallback at dams, and increase susceptibility to disease Refer to Snake River fall-run Chinook for surrogate information in Section 3.5.2.4.

Lower Columbia River Chum Salmon

Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia River chum salmon juvenile dam passage.

*Summary of Key Effects*

MO2 operations would result in more difficulty in meeting chum flows, with a 3 percent increase, compared to the No Action Alternative, of years where the flows could not be met downstream of Bonneville Dam without additional drafting of Grand Coulee. Juvenile outmigration could be slower due to decreased outflows in March, and the small proportion that pass Bonneville Dam would experience negligible increased survival at the dam. Adult migration and survival would likely be similar to the No Action Alternative.

*Larval Development/Juvenile Rearing*

How operations under MO2 affect the ability of Grand Coulee to provide winter flows to protect chum redds and provide sufficient access to habitat was calculated using hydrology modeling. Under MO2, chum flows would be met in 89 percent of years, compared to 92 percent of years in the No Action Alternative. In years when additional releases from Grand Coulee for chum would be needed, the average additional volume needed would be 0.12 million acre-feet (Maf). MO2 would result in 3 percent more years where chum flows would not be met, and agencies would thus have to decide whether to increase risk to chum eggs or reduce spring augmentation flows for spring migrating juvenile salmon.

Maintaining water saturation of 105 percent TDG or less from November 1 to April 30 appears to provide a sufficient level of protection to chum salmon eggs and sac fry incubating in the gravel downstream of Bonneville Dam in the Ives/Pierce Island Complex. In MO2, chum sac fry would be exposed to TDG above 105 percent in four out of the 80-year record modeled, all in the mid- to late April timeframe. This is one year less than the No Action Alternative where this TDG threshold would be exceeded.

*Juvenile Fish Migration/Survival*

Chum salmon only encounter one CRS project, Bonneville Dam; therefore, none of the structural measures described in common effects would apply to these fish, and only a small proportion of spawning occurs above Bonneville Dam. As there is no direct estimate of

Bonneville Dam survival specific to juvenile chum, juvenile model metrics for Snake River spring-run/summer-run Chinook salmon are used as a surrogate to estimate any change in juvenile survival for the portion that pass Bonneville.

Bonneville Dam outflows would be about 4 percent lower than the No Action Alternative in March, when chum juveniles begin outmigration. This could result in a minor increase in their travel time, thus increasing exposure to predation. Under MO2, COMPASS modeling of the surrogate species, Snake River spring/summer-run Chinook salmon, indicates that CRS operational changes are expected to result in negligible increases in survival for juvenile fish passing downstream of Bonneville Dam compared to the No Action Alternative. MO2 would not change the outmigration conditions for juvenile chum that spawn below Bonneville Dam, other than they may experience lower TDG than under the No Action Alternative.

*Adult Fish Migration/Survival*

Most chum spawn downstream of Bonneville Dam. Upstream migration of chum into the Columbia River occurs in October and November. Bonneville Dam average monthly outflows would be about 3 percent lower than the No Action Alternative in October, while in November they would be about 3 percent higher than the No Action Alternative. Adults spawning in December would encounter outflows about 7 to 13 percent higher than the No Action Alternative.

**Other Anadromous Fish**

***Pacific Eulachon***

<u>Summary of Key Effects</u>

Eulachon would continue to migrate into the Columbia River from November through March, with specific dates of migration and spawning based on a variety of environmental factors including temperature, high tides, and ocean conditions (NMFS 2017). Modeled data for MO2 (based on the period of record for Bonneville tailwater temperatures) indicate that temperatures would not be substantially different from the No Action Alternative (all temperatures would be within 0.6 degrees of the No Action Alternative.) Spawning locations and substrate conditions would not be expected to differ from the No Action Alternative.

Compared to the No Action Alternative, MO2 would have no change in the time between the peak spawning runs, egg development, and larval emergence. The spring freshet that disperses larvae to adequate food sources would continue to be highly variable, with an average of 168 days between spawning temperature triggers and peak flows (157 days in high flow years, and 158 days in low flow years).

Spring flow rates would be expected to be about 1 percent to 2 percent lower during outmigration compared to the No Action Alternative.

Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation rates on eulachon, whereas at lower flows birds tend to switch to marine prey. Under MO2, there would be a minor change (2 to 6 percent) in all months and water year types (the change is low enough to be likely immeasurable). Higher flows in winter (November to January) could pose a minor increase in predation risk when the bulk of the eulachon run is migrating up the Columbia River.

***Green Sturgeon***

Summary of Key Effects

The Columbia River use by green sturgeon is primarily foraging habitat for adults and subadults. Key effects of MO2 are focused on how flows and temperatures influence the cues for entering the Columbia River as well as the availability and distribution of food sources. Under MO2, flows in the area used by green sturgeon would be similar to the No Action Alternative (0 percent to 2 percent variation). Modeled flows indicate flows could be slightly higher in September (+2 percent), and lower in October (-2 percent), which could result in minor shifts in location for feeding from downstream in September to further upstream in October.

***Pacific Lamprey***

Summary of Key Effects

MO2 has several measures that are designed specifically to benefit lamprey. These measures are proposed structural improvements that include converting extended-length submersible bar screens to submersible bar screens, expanding the network of Lamprey Passage Structures to bypass impediments in fish ladders, changing the design for turbine cooling water strainers, replacing turbines for safer fish passage, and other physical modifications to reduce fish injury and mortality.

Larval Development/Juvenile rearing

MO2 has no measures that would either benefit or harm juvenile lamprey rearing. All ramping rates and dewatering issues would be the same in this alternative as for the No Action Alternative.

Juvenile Migration/Survival

A substantial amount of injuries and mortality can occur for outmigrating juveniles on their downstream migration including impingement on screens. Several measures would improve conditions and reduce injuries and losses. These measures are also in MO1 and their effects are described in more detail in the lamprey section in that alternative. Briefly, the measures and their anticipated effects would be:

- Converting the extended-length submersible bar screens to submerged traveling screens would substantially reduce mortality due to impingement.

- A new design of structure for exclusion of juvenile lamprey from cooling water strainer intakes would substantially reduce or eliminate this pathway of mortality.
- Additional powerhouse surface passage at Ice Harbor and McNary Projects would change the dynamics of lamprey passage. A higher percentage of lamprey would be expected to pass via the surface routes instead of the turbines in relation to the No Action Alternative, but the overall relative effect to juvenile lamprey passage is unknown.
- Replacing turbines at John Day Project with a newer design of turbine would improve conditions for fish passage and reduce the injury rate for lamprey.
- Ceasing the installation of fish screens at Ice Harbor, McNary, and John Day Projects would eliminate the effects of lamprey impingement on screens.

Because of the high degree of uncertainty surrounding how many juvenile lamprey are lost or injured on their downstream migration, it is difficult to quantify the improvement represented by all of the measures. For fish that encounter multiple dams on their migration downstream, reducing the total number of hazards would increase their probability for survival to adult life stage.

<u>Adult Migration/Survival</u>

Similarly, there are measures in MO2 that were also in MO1 and that improve adult lamprey passage. These include:

- Expanding the network of lamprey passage structures would improve lamprey passage.
- Modify the upper ladder serpentine flow control ladder sections at Bonneville Dam would reduce migration delays caused by baffles in this section.
- Adding cooler water in the fish ladders at Lower Monumental and Ice Harbor would be expected to benefit lamprey because this has been successful at Little Goose and Ice Harbor.
- Modifications to Lower Monumental include diffuser grate plating. This has been done at all other ladders except Lower Monumental and demonstrated slight benefits to lamprey passage.

Each structural measure in MO2 that targets lamprey is intended to increase their dam passage efficiency either by getting fish to enter rather than turn back from the fishway, or to increase successful passage to continue migrating. See MO1 for more details on effects of these measures. Collectively they would provide incremental improvements to adult migration and survival.

The overall expected improvements in lamprey passage efficiency should decrease susceptibility to physical stress and mortality, and shorter holding time would be beneficial to the fish. These structural measures for lamprey are expected to provide an incremental benefit to the population size and distribution of Pacific lamprey in the Columbia Basin. Compared to the No Action Alternative, all proposed structural measures to reduce losses would have benefits to the population and recruitment to the next generation. The combined effect of all proposed structural modifications would be a substantial improvement for lamprey survival and fitness. However, most of the water management and water supply operational measures have no benefit and might make migration conditions worse for juvenile lamprey compared to the No Action Alternative.

***American Shad***

<u>Summary of Key Effects</u>

No change is anticipated to juvenile shad because plankton communities and shoreline habitat would not change in MO2. The proportion of adult shad counted at Bonneville Dam that migrate upstream past McNary Dam is expected to increase under this alternative due to decreases in outflows during shad migration months.

**RESIDENT FISH**

**Region A**

***Kootenai River Basin***

<u>Summary of Key Effects</u>

MO2 would have the same key effects as the No Action Alternative. Discharges from Libby Dam would continue to have detrimental effects to fish species in the Kootenai River downstream of Libby Dam. Spring water temperatures would continue to be too cold for optimum development of some aquatic species. Spring flows would also continue to increase at a rate similar to the No Action Alternative, with ongoing delay and impaired productivity associated with inundated riparian and varial zone habitats in the river corridor from the dam to Kootenay Lake in British Columbia. These reduced flow rates would also continue to limit productivity and may adversely impact kokanee and their food sources downstream of Libby Dam.

Under the MO2, cottonwood seedlings would continue to have variable survival depending on timing, stage and duration of spring flows, along with winter stage during the ensuing winter. In addition, the discharge regime from Libby Dam would not provide for successful burbot recruitment, and spring water temperatures would be too cold to allow for proper larval development.

<u>Habitat Effects Common to This Fish Community</u>

MO2 would not change water temperatures in the spring from those under the No Action Alternative. However, MO2 would provide deeper end-of-December drafts than the No Action Alternative, with deep drafts of 26.7 feet in some years that may enhance reservoir warming during the spring and early summer.

Under MO2 there would be a lower rate of flow increase from Libby Dam between mid-March and mid-May than the No Action Alternative This decrease in flow rate under MO2 would result in a greater delay in commencement of river productivity than under the No Action Alternative.

MO2 would decrease the potential for cottonwood and willow seeding and recruitment compared to the No Action Alternative. Under MO2, there would be fewer days when the winter peak stage does not exceed the seeding peak stage. There would also be a smaller difference in river elevation between the winter and spring peak stage at Bonners Ferry when compared to the No Action Alternative.

MO2 would not differ from the No Action Alternative in the rate of recession of river stage at Bonners Ferry during the seeding season.

Bull Trout

Effects to bull trout under MO2 that differ from those of the No Action Alternative include lower minimum and maximum water levels at Lake Koocanusa, lower flows below Libby Dam, less habitat for adult bull trout, but more habitat for juvenile bull trout.

Under MO2, Lake Koocanusa would be above elevation 2,450 feet for two more days than under the No Action Alternative. This short period would not be sufficient to have different effects on the Bull trout population than the No Action Alternative.

The median minimum elevation of Lake Koocanusa under MO2 would be 11 foot lower than under the No Action Alternative, but the drier forecast years could be ten to twenty feet deeper. These elevations would increase the risk of annual dewatering and decrease benthic insect production, which could result in a decrease in bull trout growth and/or survival. However, in wet years, MO2 would provide a shallower draft and may be more beneficial to benthic insect production during those years. At the same time, the maximum elevation of Lake Koocanusa under MO2 would be 1 foot higher than under the No Action Alternative. This may result in slightly higher terrestrial insect deposition under MO2.

Under MO2, Libby Dam would provide discharge of 20 kcfs or greater for two less days than under the No Action Alternative. These flows would be insufficient to mobilize or reshape tributary deltas that can prevent bull trout access during the late summer and early fall. MO2 would have lower discharges than the No Action Alternative and would provide less usable habitat for adult bull trout, but more usable habitat for juvenile bull trout than the No Action Alternative.

Kootenai River White Sturgeon

On average, MO2 would provide one less day than the No Action Alternative when flows are greater than or equal to 30 kcfs at Bonners Ferry between May 15 and July 15. This reduction in the number of days with high flows would not differ biologically in the number of spawning adult Kootenai River white sturgeon that migrate to spawning habitat upstream of Bonners

Ferry when compared to the No Action Alternative. However, in dry water years, flows would be more than 24 percent lower during this critical period and could reduce the spawning and recruitment of Kootenai River white sturgeon.

Other Fish

The median minimum elevation of Lake Koocanusa under MO2 would be one foot, but the drier forecast years could be ten to twenty feet lower. These conditions would have the same effects identified in the discussion above for bull trout.

Under MO2, there would be fewer days when Libby Dam would provide a discharge of 20 kcfs or greater when compared to the No Action Alternative. In addition, the mean flow rate under MO2 would be less than under the No Action Alternative. These flows would be insufficient to mobilize or reshape tributary deltas that can prevent bull trout access during the fall spawning season.

MO2 would have slightly lower discharges from Libby Dam for the period May 15 to September 30 than the No Action Alternative but would provide slightly more usable habitat for juvenile and adult redband rainbow trout than the No Action Alternative. Higher usable habitat may result in increased growth and/or survival of all life stages of redband rainbow trout.

Changes in effects to burbot under MO2 include reduced flows. Median flows under MO2 as measured at Bonners Ferry between January 1 and April 30 would be lower than those under the No Action Alternative. These flows would be more likely than the No Action Alternative to provide the low and stable flows that imitate pre-dam hydrographs during burbot spawning and incubation, and thus most conducive to successful burbot recruitment.

***Hungry Horse/Flathead/Clark Fork Fish Communities***

Summary of Key Effects

The key effects of MO2 are largely biological responses to changes in Hungry Horse Reservoir elevations and outflows to provide additional power generation in winter. Benthic insect production important to fish would be appreciably decreased under MO2. Lower surface elevations could also increase issues with predation/exploitation risk as fish migrate into and out of tributaries to fulfill their life cycles, although bull trout would likely not be as affected because of their migration timing. Increased outflows in winter would likely result in increased entrainment of zooplankton and fish out of Hungry Horse reservoir. Winter habitat and food supply would be adversely affected in the South Fork Flathead River and mainstem Flathead River. MO2 would have negligible effects on Flathead Lake fish other than to populations that migrate into the Flathead River, and fish in the lower Flathead River and Clark Fork Rivers would encounter more stressful conditions due to flow fluctuations and increased winter flows.

Habitat Effects Common to This Fish Community

Winter elevations would be lower than the No Action Alternative. In wet and average years, deeper drafts in winter would result in much lower elevation upon starting refill, so with all year types considered, there would be a 67 percent annual probability of reaching elevation 3,559 feet by July 31, meaning 8 more years more out of 100 that would not reach full compared to the No Action Alternative. In fall months, the elevation would be the same as the No Action Alternative, but beginning in January, MO2 reservoir elevations in wet and average years would be steeply drafted, ending the draft about seven lower than the No Action Alternative. Elevations from February through April would be 4 to 8 feet lower than the No Action Alternative. Dry year elevations would be similar through the fall and winter.

Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry Horse reservoir. The zooplankton enhances food supply in the South Fork Flathead River and along the near bank of the Flathead River but decreases food supply for fish in Hungry Horse Reservoir. Outflows, and therefore zooplankton entrainment, under MO2 would be roughly double the loss as compared to the No Action Alternative in January and into February, and see spikes in entrainment when flows peak and drop in April and May. Fish entrainment would also follow a similar pattern.

Outflow patterns from Hungry Horse Reservoir can also affect insect production and the habitat conditions, such as river elevation (stage), velocities, and temperatures in the river. These effects continue downstream to affect the main Flathead River in the same patterns, but somewhat attenuated by the flows in the mainstem Flathead. Temperatures in summer are regulated with a selective withdrawal structure that is operated to release water of a temperature that favors native fish. The temperature control structure would continue to operate in summer under MO2 operations. In winter, the temperature control structure is not operated, and MO2 January and February outflows would be roughly double (or more in some year types) compared to the No Action Alternative. Extreme fluctuations between high and low flows would disrupt the production of aquatic insects every time flows are increased for a time and then dropped again. Due to the removal of ramping rate restrictions there could potentially be large fluctuations in outflows throughout the year that would cause disruptions to the aquatic insects; successful recruitment of these important food sources would likely fail. These extremes in flows in winter would also substantially reduce habitat for native fish due to increased velocities making much of the habitat unsuitable.

In the Flathead River down to Flathead Lake, habitat suitability is a key issue due to extremely high flows in winter and in late summer. Under MO2, January outflows in wet years would nearly double compared to the No Action Alternative. Winter flows of that magnitude could decrease the amount of suitable habitat for native fish by over 30 percent in wet years and over 20 percent in average years (Muhlfeld et al. 2011). Higher-than-normal winter flows would continue to limit establishment of riparian vegetation important to fish, and spring peaks only slightly lower than the No Action Alternative would continue to occasionally provide flushing of sediments from gravels to maintain habitat. Summer temperatures would continue to be similar to the No Action Alternative because the temperature control structures would continue to operate. Higher flows in winter would increase the proportion of South Fork Flathead River flows in the mainstem Flathead River; this would increase the temperature in the mainstem Flathead River because South Fork Flathead River flows would be warmer than mainstem flows.

Increased temperatures in winter could favor non-native fish over native fish, such as bull trout and westslope cutthroat trout, due to changes in productivity and metabolism. the Similar to the South Fork Flathead River described in the preceding paragraph, the removal of ramping rate restrictions there could potentially be large fluctuations in outflows throughout the year that would that would cause disruptions to the aquatic insect production in the mainstem Flathead River as well as increase stress on fish seeking out suitable habitat.

The winter water temperature warming influence from the contribution of the South Fork Flathead River would be higher in MO2 with higher winter outflows. The increased flows in the South Fork Flathead would contribute a greater proportion of reservoir water that would be warmer than river water, resulting in a larger departure from normalized temperatures than the No Action Alternative. TDG in the Flathead River would be similar to the No Action Alternative, continuing to fluctuate with spill at Hungry Horse Dam but generally would not exceed 117 percent, which is within a safe zone for fish.

The influence of MO2 changes to Flathead Lake levels would be minimal. Median outflows in January would be 43 to 53 percent higher than the No Action Alternative, and February median flows would be 6 to 19 percent higher. Median April, May and June flows would be 4 to 6 percent lower, and increased fluctuations would be expected compared to the No Action Alternative. In lower flow years, median summer flows would also be 5 to 6 percent lower.

<u>Bull Trout</u>

Under MO2, Hungry Horse Reservoir summer phytoplankton and zooplankton production would be minimally affected compared to the No Action Alternative. However, failing to refill more often than the No Action Alternative would result in a smaller area for aquatic insect production in those years, and steep drafts in winter would greatly reduce production of aquatic insects. Insects that had overwintered for the following spring would not be available for juvenile bull trout moving into the reservoir in the spring, and prey base for adult bull trout would be reduced. The lower reservoir elevations would result in a decrease greater than 4 to 8 percent of surface area for benthic insect production all winter, especially in the bays at the upper ends of the reservoir lobes, and the steep drops would reduce the production of the large, 2-year invertebrates. Juvenile bull trout moving into the reservoir in the spring rely on the benthic insects until they transition to eating fish. The prey items that adult bull trout eat also consume the benthic insects and may be in poorer condition or less plentiful in areas. Zooplankton are an important winter food source for bull trout so increased entrainment of zooplankton would decrease their food supply in January and February. These changes in food sources could result in bull trout being in poorer condition.

Under MO2, elevations in August or September would be either similar to the No Action Alternative or slightly higher (in dry years). Varial zone effects to bull trout would be similar to the No Action Alternative.

Bull trout entrainment through the dam would likely increase in MO2 due to increased outflows in winter. Entrainment would be about double the No Action Alternative in January in wet and average years and February of wet years. Lower monthly outflows in spring would likely result in lower entrainment in April through June. Bull trout are likely to be near the dam during overwintering, but they would not be as concentrated there as they would be in late summer months. Late summer entrainment would be similar to the No Action Alternative. Entrainment has not been quantified but would be expected to increase under MO2 compared to the No Action Alternative.

The number of individual bull trout in the South Fork Flathead River below Hungry Horse Reservoir may increase with greater entrainment, but these would be lost from their spawning populations, and would be deposited in the South Fork Flathead River during high flows that limit habitat suitability. Zooplankton available in the South Fork Flathead River may increase in winter with higher outflows, but aquatic insect production would be heavily disrupted with frequent fluctuations. As in the reservoir, food web relationships are important. The MO2 operations would likely continue to allow for this transitory use by bull trout and other native fish at most times of the year, but adequate food and habitat may become limiting. Increased outflows in winter would result in much lower availability of suitable habitat for bull trout due to higher velocities.

Winter flows in the mainstem Flathead River would be much higher than the No Action Alternative, further exacerbating issues with habitat suitability. Relationships described in Muhlfield et al. (2011) between winter flows and bull trout habitat suitability indicate that bull trout habitat would be reduced by 20 percent to 30 percent in wet and average years under MO2. Nighttime habitat use by subadult bull trout would be most disrupted. At all times of the year, more extreme fluctuations would cause stress for bull trout in the mainstem Flathead River and would limit food production in this reach.

The lake elevations of Flathead Lake would be similar to the No Action Alternative, as would the bull trout habitat use and life history functions in Flathead Lake. Changes described above, though, would affect bull trout from this population as they migrate into the mainstem Flathead River.

MO2 would change the operations of Seli'š Ksanka Qlispe' Dam into the Lower Flathead River in a similar pattern as Hungry Horse operations. Outflows would be much higher in winter months and experience more variability throughout the year. The higher flows would come at a time when the area near the dam provides suitable temperatures for bull trout, so they could be subject to entrainment. Entrainment of bull trout from Flathead Lake could increase by 43 to 53 percent in January and 6 to 19 percent in February. Entrained bull trout become lost from the spawning populations. Bull trout in the Lower Flathead River may experience stress as they move into freshly inundated habitats as flows increase but there would not be food available in these habitats. Decreases in flows in May and June would likely not affect bull trout in the lower river at that time of year. In summer, temperatures would make this area mostly unsuitable for bull trout under both the No Action Alternative and MO2.

<u>Other Fish</u>

Hungry Horse Reservoir would continue to favor a native fish-dominated fish community under MO2. There could be effects to native fish, but the habitat is somewhat protected from non-native fish invasion by the dam. Juvenile bull trout and adult whitefish, northern pikeminnow, sculpins, and westslope cutthroat trout feed on zooplankton, aquatic insects, and terrestrial insects, and adult bull trout prey on mountain whitefish, suckers, minnows, etc. The food web effects described above would also apply to all of these species of fish in Hungry Horse Reservoir. Zooplankton and summertime feeding of terrestrial insects would be similar to the No Action Alternative. Substantial decreases of at least 4 to 18 percent in aquatic macroinvertebrates would be expected due to reduced habitat, and dewatering events would further reduce the food supply for many of these fish.

Westslope cutthroat trout and other native fish spawn in the spring (April through June) so effects on adults migrating into tributaries to spawn would differ from bull trout. Spring spawning fish migrate when reservoir levels are lower and tend to experience longer varial zones with increased predation exposure. Under MO2 operations, the modeled April and May elevations were 5 to 7 feet lower than the No Action Alternative in wet and average years, and similar in dry years. By June, the elevations would be similar to the No Action Alternative. Spring spawning fish such as westslope cutthroat trout would experience greater varial zone effects on their way upstream as adults, and they could encounter some tributary blockages, but the delta formation of these tributaries is not known. Juveniles typically outmigrate in June when the effects would be similar to the No Action Alternative.

Entrainment from the reservoir would also continue at unquantified levels and could increase in the winter months with increased outflows. By winter, all species of fish can be distributed throughout the reservoir; entrainment has not been quantified but would be roughly twice as much as the No Action Alternative in winter months.

Habitat suitability described for bull trout would be similar for other native fish (Muhlfield et al. 2011) in the mainstem Flathead River, with higher winter flows in MO2 resulting in decreased amount of suitable habitat, and food supply becoming scarcer with decreased aquatic invertebrates.

Fish in Flathead Lake would be mostly unaffected by changes in operations in MO2. The lower Flathead River and Clark Fork Rivers would provide conditions that would be more stressful to fish with rapid and more frequent fluctuations in outflows. In these scenarios, juvenile fish, especially, would be forced to seek refuge from increased flows into newly inundated habitats where no food would be available.

#### *Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River*

Summary of Key Effects

Key effects under MO2 include a slight reduction in flows March through June that would reduce the threat of fish entrainment through Albeni Falls Dam relative to the No Action Alternative.

Habitat Effects Common to All Fish

Habitat effects from MO2 common to all fish would include the flow reduction identified above in the summary of key effects section.

Bull Trout

Flows would be lower in March through June under MO2 compared with the No Action Alternative. As a result, the potential for bull trout entrainment would be slightly less under this alternative.

Other Fish

The mean flow under MO2 would be reduced by up to 2.7 percent, depending on the time of year, when compared with the No Action Alternative. Consequently, the potential for the entrainment of other resident fish, including kokanee, westslope cutthroat trout, and northern pike, would decrease slightly under this alternative.

### Region B

#### *Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam*

Summary of Key Effects

Flow, elevations, and water quality affect the quality of habitat for various resident fish species above, in, and downstream of Lake Roosevelt. The Columbia River from the U.S.-Canada border would continue to support a white sturgeon population that spawns successfully but primarily relies on fish manager intervention to survive a recruitment bottleneck; conditions for natural recruitment may be further diminished in a small proportion of years. In Lake Roosevelt, retention time is a key metric for most fish species, driving the food web that supports the fish as well as influencing how many are entrained and would be lower in winter than the No Action Alternative. Lake elevations under MO2 would increase risk of impeded tributary habitat access and egg drying out or stranding for redband rainbow trout. The portion of kokanee that spawn in tributaries would continue to have access in fall similar to the No Action Alternative, except conditions could be more difficult in dry years. Reservoir operations would continue to result in some level of eggs drying out of the burbot spawn and the portion of kokanee that spawn on lake shorelines and would increase in MO2 compared to the No Action Alternative. These effects would be a higher magnitude than MO1. MO2 would continue to support both wild and hatchery-raised kokanee, redband rainbow trout, and hatchery rainbow trout as well as non-native warmwater game species, such as walleye, smallmouth bass, and northern pike, with some effects to populations. However, decreased water retention times are expected to adversely influence reservoir productivity and increase entrainment. Northern pike would likely continue to increase and invade downstream, and the lake elevations could decrease the ability for boat suppression efforts. Rufus Woods Lake would continue to provide habitat for fish entrained from Lake Roosevelt and from limited production of shoreline spawning by some species; entrainment could increase in winter and decrease in summer months. TDG would be similar or less than the No Action Alternative.

Habitat Effects Common to This Fish Community

The elevation hydrograph for MO2 is very similar to MO1. Median peak outflows would follow the same pattern as the No Action Alternative with peaks in early June and another smaller peak in July. MO2 spring flows are the same as the No Action Alternative. October flows would be about eight to nine percent lower than the No Action Alternative, and December flows would be about eight to fifteen percent higher than the No Action Alternative. These peak outflows can influence the rate of entrainment from Lake Roosevelt into Rufus Woods Lake. TDG in the Grand Coulee tailwater is also a concern for fish in Rufus Woods Lake. Under MO2, TDG would be lower than the No Action Alternative.

Retention time of water through the reservoir is a driving metric for the food web in Lake Roosevelt and influences the populations of several fish species. Generally speaking, under MO2 median retention time would be similar to MO1. Both would be similar to or slightly higher than the No Action Alternative in late spring, summer, and fall. Retention time under MO2 would be nine percent higher in all year types in October, 13 percent lower in December, and three percent to nine percent lower in January than the No Action Alternative. February would be six percent lower in dry years and 17 percent lower in wet years. In wet years is when retention time is lowest because more water is moving through the system, and MO2 would reduce retention times even further in winter.

Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely directly on the food source provided by the zooplankton production, and higher-level predators such as bull trout prey on these fish. Zooplankton are more widespread, more plentiful, and have a larger body size when retention times are higher, and tend to be smaller bodied, swept out of the reservoir faster, and more concentrated near Grand Coulee Dam with a lower retention time. With lower retention times under MO2 in winter and spring, when retention times are already fairly low, there would be less food available to fish, and they would also tend to follow the food source and crowd down towards the dam, becoming more susceptible to entrainment. These are the same mechanisms of effects as MO1 but at higher magnitudes for a moderate effect. Decreased retention time in September in MO2 would flush out zooplankton that provide key winter food sources.

Bull Trout

Bull trout are temperature sensitive and would continue to use this reach for foraging, migration, and winter habitat until temperatures reach stressful levels that would be the same as the No Action Alternative. Bull trout in Lake Roosevelt could continue to move to cooler locations in the reservoir, and these refuges would remain similar to the No Action Alternative. High flow years would continue to influence bull trout distribution through flushing more of them from the river near the U.S.-Canada border down into Lake Roosevelt. Peak flows at the U.S.-Canada border were modeled showing flows similar to the No Action Alternative. Similar to MO1, increased outflows in December could potentially increase entrainment of bull trout, but this is negligible because of the scarcity of bull trout in Lake Roosevelt.

Bull trout prey base would continue to fluctuate, as the fish they eat are sensitive to changes in productivity and location of zooplankton in Lake Roosevelt that is influenced by the retention time of water in the reservoir, which would be adversely affected by lower retention times in winter under MO2. Bull trout are also sensitive to contaminants that are found in this region and would continue to bioaccumulate contaminants as a top predator. Similar to MO1, fluctuation events that mobilize mercury would be the same as the No Action Alternative.

Other Fish

In the Columbia River reach from the U.S.-Canada border to Lake Roosevelt, white sturgeon are typically able to spawn as evidenced by capture of young of the year larvae (Howell and McLellan 2018), but rarely experience successful recruitment from larvae to juvenile sturgeon, and only in extremely high water years. Successful recruitment appears to be dependent on a combination of flows exceeding 200 kcfs and water temperatures of about 14°C for 3 to 4 weeks in late June/early July (Howell and McLellan 2011 and Howell and McLellan 2014). In MO2, flow over 200 kcfs in June and July would be slightly decreased. The timing of these flows coinciding with lower reservoir levels can also increase recruitment ability with the longer riverine habitat provided by a lower reservoir. MO2 reservoir levels would be very similar to the No Action Alternative and the time window for white sturgeon recruitment would be the same as the No Action Alternative. Other factors that would continue to influence sturgeon include predation by fish that are favored by reservoir conditions if larvae are flushed into the Lake Roosevelt. Spring flows would be the same as the No Action Alternative. The uptake of contaminants such as copper closer to the U.S.-Canada border being flushed downstream into the reservoir by high flows would also be the same as the No Action Alternative. Under MO2, recruitment of white sturgeon would continue to be a rare event supplemented by hatchery propagation, as larval sturgeon are captured and raised in hatcheries until they are past the time window where recruitment has been shown to fail at a high rate. Once these juveniles are released back into the reservoir they continue to grow and survive well. The reservoir would continue to provide good conditions for growth and survival of these fish.

Wild production of native fish such as burbot, kokanee and redband rainbow trout would continue to provide valuable resources in Lake Roosevelt. As described in the common habitat effects, these fish are the most sensitive to the effects of changing retention times. Under the

No Action Alternative an estimated average of over 400,000 fish annually would be entrained, with 30 to 50 percent of them being kokanee, primarily of wild origin and rainbow trout the second most entrained species. Under MO2 operations, increased entrainment would be expected in winter months as the outflows increase over the No Action Alternative, and retention times would be 12 percent to 13 percent lower in December and 3 percent to 9 percent lower in January. Previous entrainment studies (LeCaire 2000) indicated winter being a period relatively low entrainment. The prolonged drawdown period is expected to increase entrainment in winter months under MO2. In wet years entrainment would also be higher in March to May (2 percent to 6 percent lower retention time) which could increase entrainment at a disproportionately high rate. Decreased food sources due to flushing of zooplankton in fall could limit kokanee growth, and juvenile burbot rely on this food as well.

For tributary spawning species such as redband rainbow trout and a portion of the wild production of kokanee, tributary access at the right time of year is important. Reservoir drawdown in the spring creates barren tributary reaches through the varial zone, which directly and indirectly impedes migration to and from tributaries and the reservoir. The operational metric of reaching a lake elevation of 1,283 feet by the end of September would be met under MO2 in wet and average years and would protect the access for the portion of kokanee that spawn in tributaries. In dry years, the reservoir would only reach elevation of 1,279 feet by September and may cause some access issues. Redband rainbow trout need access to tributaries in the spring. Under MO2, similar to MO1, reservoir elevations would be lower than the No Action Alternative levels in the critical spawning migration time of April-May in wet and dry years (equaling about 40 percent of years). This would be most critical in wet years (20 percent of years) when the median elevation would be 1,241 feet on April 1, which is lower than the No Action Alternative. Migratory impacts, although not well documented, could be severe for Redband rainbow trout given the timing and extent of drawdowns in MO2. Redband rainbow trout spawn in Sanpoil, Blue Creek, Alder, Hall Creek, Nez Perce Creek, Onion Creek, Big Sheep Creek, and Deep Creek. These tributaries higher in the basin are more susceptible to elevation changes, because a smaller change in lake elevation would result in a larger area of exposure than tributaries closer to the dam. Additionally, increased exposure during migrations to these tributaries would increase the varial zone effect where migrating fish are more exposed to predation and angling due to lack of cover.

Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible to eggs drying out if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on shoreline gravels September 15 to October 15 and eggs incubate through February. Burbot tend to spawn successfully in depths provided by the No Action Alternative in the Columbia River and in Lake Roosevelt on shorelines near the Colville River in winter with eggs incubating through the end of March (Bonar et al. 2000). MO2, like MO1, would begin dropping 2 months sooner than the No Action Alternative and would likely strand or dewater burbot and kokanee eggs. A higher proportion of eggs at all elevations would be affected.

The portion of kokanee that spawn in the shallower 6 feet of elevations could have eggs dry out when these drops occur. Any eggs near the fall surface elevation would be at higher risk. Fry sometimes also stay in the gravels and could become stranded as well. Burbot spawn later in the winter so would be less affected because the lake level would have already dropped seven feet lower than the No Action Alternative when eggs would be deposited. However, this same mechanism would also decrease habitat available compared to the No Action Alternative. The wet years would have steeper and deeper reservoir draft than the No Action Alternative and would result in increased stranding of burbot eggs. The magnitude of this effect is even higher than MO1 because MO2 would drop steeper in February than MO1, both of which would be considerably more drop than the No Action Alternative.

Kokanee are very sensitive to water temperature, and during summer are found at depths below 120 m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is very weakly stratified but does have suitably cool water at this depth along with suitable levels of DO. Lake whitefish and mountain whitefish also likely use this cool water in the summer.

Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish, crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all tolerate a wide range of environmental conditions and would continue to contribute to the fishery community under the No Action Alternative, and continue to adversely impact native species via predation. The invasion downstream by northern pike is of concern, and the Lake Roosevelt Co-Managers are actively suppressing pike populations using gillnets set by boats as soon as they can get on the water in the spring until the boat ramp becomes unusable at elevation of 1,235 feet. Under the No Action Alternative, this occurs on April 15 in wet years, and would not occur at all in dry and average years. Like MO1, under MO2 in wet years this would occur up to 6 days and preclude the ability for the pike suppression efforts for that period. For estimation purposes, one crew typically removes about 100 pike per week and they would operate three crews (Colville Tribe unpublished data), so the lost opportunity of up to 6 days under MO2 could result in an estimated 300 pike not removed. Additionally, outflows and retention time would continue to influence the entrainment and downstream invasion of non-native gamefish below Chief Joseph Dam where ESA-listed anadromous salmonids would be susceptible to predation by them. During the time when pike juveniles would be most susceptible to entrainment, (May to August), retention time under MO2 would be similar or slightly higher so entrainment risk for juvenile pike could be similar to the No Action Alternative or slightly lower. However, as pike distribution increases downstream in the reservoir, adults and juveniles both would become more susceptible to entrainment and the increased winter outflow would increase entrainment.

Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt would experience similar effects as their native counterparts except for spawning and early rearing effects. In addition, the net pen locations are situated where the water quality can be affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG, and their eventual recruitment to the fishery can be affected by retention time coupled with reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May. Under the MO2, the water quality at these locations would be similar to the No Action Alternative in most locations, although a decrease in DO was shown in the Spokane arm, which could reduce the suitability of that location. The retention time in May would be either similar or slightly higher so entrainment risk would be the same as the No Action Alternative or slightly less. The operators strive to release these fish to coincide with the initiation of reservoir refill when outflows are reduced, which under MO2 would be the same as the No Action Alternative, so these fish would continue to be release when water quality conditions would be suitable.

The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter drawdown periods. The earlier start to winter drawdown and increased outflows for power generation in MO2 may increase entrainment and boost populations in Rufus Woods Lake. Decreased outflows in August and September likely would decrease entrainment. This lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short retention time and low productivity. High flows during late spring and early summer would continue to flush eggs and larvae from protected rearing areas similar to the No Action Alternative, but slightly lower magnitude. Median peak outflows occur in early June and would be about 3 percent lower than the No Action Alternative. TDG in the Grand Coulee tailwater is a concern for fish in Rufus Woods Lake; modeling showed TDG would be lower than the No Action Alternative.

***Chief Joseph to McNary Dam***

<u>Summary of Key Effects</u>

Key effects from alternative MO2 would not be different from the No Action Alternative.

<u>Habitat Effects Common to All Fish</u>

Habitat effects from alternative MO2 common to all fish would be similar to those found in the No Action Alternative.

<u>Bull Trout</u>

Important effects to bull trout under alternative MO2 would not be different from the No Action Alternative.

<u>Other Fish</u>

Effects of alternative MO2 to the current fish community in this reach of the Columbia River would be similar to the No Action Alternative.

**Region C**

***Snake River Basin***

<u>Summary of Key Effects</u>

Effects from MO2 that differ from the No Action Alternative would include decreases in dam passage survival for fish passing downstream, lower water levels at Dworshak Reservoir that would reduce connectivity with tributary streams, reduced levels of TDG from lower spill volumes, and increased risk of kokanee entrainment at Dworshak Reservoir from increased winter flows.

<u>Habitat Effects Common to All Fish</u>

Common habitat effects of MO2 are similar to those identified for the No Action Alternative with the exception of the changes discussed in the section above.

<u>Bull Trout</u>

Effects to bull trout from MO2 would include a slight increase in mortality from downstream passage of the lower Snake River Dams. Reductions in spill and associated TDG that would reduce the risk of GBT to bull trout in May and June, and large reductions in pool elevations at Dworshak Dam from May through July that would decrease connectivity of reservoir and tributary habitats. Under MO2 more flow would be put through turbines relative to the No Action Alternative. Because turbine survival is generally lower than spillway or bypass survival there would be a minor increase in mortality of bull trout routed through these turbines.

Because relatively more flow would be routed through the powerhouse at the Snake River dams under MO2, spill would be reduced, as would the risk of GBT for all species of fish.

Under MO2, winter releases from Dworshak Reservoir would be increased considerably. Reservoir pool elevation could be lower in June, which could increase migratory risks for bull trout in a much larger varial zone.

<u>Other Fish</u>

Effects of MO2 to white sturgeon would be similar to those for bull trout. Downstream passage at dams in the lower Snake River would be associated with increased mortality relative to the No Action Alternative while risks of GBT would decrease as spill and TDG are reduced.

Effects of MO2 to other resident fish species would also be similar to those for bull trout. Kokanee, particularly, in Dworshak Reservoir tend to congregate towards the dam during winter, and median winter outflows would be three times higher than the No Action Alternative in January and 40 percent higher in February in median years. This magnitude of outflows would likely result in major increased kokanee entrainment out of Dworshak. In the lower Snake River, downstream passage of fish through CRS projects would be associated with increased mortality relative to the No Action Alternative while risks of GBT would decrease as spill and TDG are reduced.

## Region D

### *Mainstem Columbia River from McNary Dam to the Estuary*

Summary of Key Effects

Bull trout would continue to use the Columbia River in limited numbers and seek thermal refugia available at the mouths of tributaries. White sturgeon would continue to successfully reproduce in years with adequate flow and temperature conditions.

Habitat Effects Common to this Fish Community

Outflows from McNary Reservoir influence some of the fish relationships described in this section. Peak spring flows affect habitat maintenance for some species. Modeled median outflows for MO2 indicate that outflows would be within 2 percent of the No Action Alternative (no discernable change).

Other flow parameters referred to in this section refer to outflows of McNary Dam, which are indicative of flows on downstream through the other Projects.

Bull Trout

Bull trout are known to use the mainstem Columbia River to move between tributaries and have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et al. 2016). Water temperature is the most important habitat factor for bull trout in the mainstem Columbia. Under MO2, bull trout would continue to use the mainstem Columbia for migration between tributaries, as well as tributary mouths for passage and thermal refugia.

Passage through turbines can cause injury or mortality. MO2 includes turbine replacement, with IFP turbines, which would improve survival (Deng et al. 2019). At John Day, turbine replacement would provide safer passage for any bull trout that move through the dam.

Bull trout would continue to be subject to bird predation.

Other Fish

Under MO2, white sturgeon spawning and recruitment would be similar to the No Action Alternative during high and average flow years. In low flow years, it is likely that there is very little spawning and recruitment anyway, but overall conditions would be similar to the No Action Alternative.

Model results indicate suitable spawning temperatures would be similar to the No Action Alternative. In years of low flow conditions, water temperatures could increase beyond the suitable range by early June, resulting in little or no recruitment.

White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse substrates (Parsley et al. 1993). Minor changes in outflow under MO2 would not be large enough to cause discernable velocity changes that would affect sturgeon spawning habitat.

MO2 does not include any measures to improve passage at the dams for sturgeon.

White sturgeon larvae are adversely affected by TDG. Studies have shown high rates of altered buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al. 1998). Adults are more able to compensate for increased TDG by moving to lower depths, but larvae in shallow water would be more affected. Under MO2, TDG rates would less than the No Action Alternative, because spill rates would be limited to 110 percent TDG.

MO2 would be similar to the No Action Alternative in terms of pool fluctuation (potential juvenile stranding), predation from pinnipeds and warmwater game fish, and reservoir maturation.

Under MO2, no changes to resident fish communities would be expected. As shown above, outflow rates below McNary Dam would be very similar to the No Action Alternative. Water quality and food availability would also be similar to the No Action Alternative.

Conditions that promote lower water temperatures and higher spring flows tend to lower the survival rates of warmwater game fish, potentially lowering populations of predators on salmon and steelhead. MO2 would be expected to continue supporting warmwater game fish at levels similar to current conditions.

**MACROINVERTEBRATES**

Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under MO2. For more detailed information on the effects of MO2 on aquatic invertebrates and implications on food web interactions see the Habitat Effects section of these respective fish community analyses in the Resident Fish section under the applicable region.

**Region A**

At Hungry Horse reservoir, the varial zone that provides benthic insect production would be similar to the No Action Alternative in the summer, except that the reservoir would miss filling more often due to lower winter elevations. Winter elevations would be about four to eight feet lower than the No Action Alternative and be drafted faster. There would be less habitat and aquatic insects in this zone would become dewatered faster than under the No Action Alternative, which would especially impact the insects with two-year life cycles. The elevation at the end of September would be similar to the No Action Alternative, with dry years actually slightly higher than the No Action Alternative due to implementing a sliding scale. With similar summer elevations, the euphotic zone for summer zooplankton production would be similar. However, increased numbers of zooplankton would leave out of the reservoir and into the South Fork Flathead River with higher outflows in January and February (often more than double those of the No Action Alternative) and in April and May. These outflows would increase zooplankton levels and wetted area for macroinvertebrate production in the South Fork Flathead River, but water level fluctuations in the South Fork Flathead River in January to February, April to May, May to June, and June to July would all cause disruptions to the aquatic insects. These fluctuations would not allow enough continuous time at steady river elevations for invertebrates to fulfil their life cycle. Additionally, higher flows would flush more macroinvertebrates out of the immediate downstream area with higher velocities than the No Action Alternative. This flow pattern would continue to the mainstem Flathead River and increase wetted area there but also dewater macroinvertebrates with frequent fluctuations, reduce amount of low velocity habitat, and flush macroinvertebrates out of the river downstream into Flathead Lake. Increased winter flows would continue downstream through the Clark Fork River and could slightly increase aquatic invertebrate habitat in winter.

The MO2 operations of the Albeni Falls Project would result in similar lake elevations as the No Action Alternative, but increased inflows from upstream in January would be passed through so inflows to the Pend Oreille River would about 22 percent higher in January. Macroinvertebrate communities could occupy those habitats but would become dewatered as flows recede again in February.

In the Kootenai basin, Lake Koocanusa would be held above elevation 2450 for a similar duration as the No Action Alternative; overall productivity of zooplankton and macroinvertebrates in the system would be similar. Likewise, MO2 operations would result in a median minimum pool elevation within a foot of the No Action Alternative and typically slightly lower, exposing similar or slightly less varial zone production to dewatering.

**Region B**

The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic insects such as stonefly, caddisfly, and mayfly larvae. The river elevation in this reach is influenced by Lake Roosevelt operations and inflows so is somewhat variable, which would constrain benthic production to some degree.

MO2 operations would be very similar to MO1. This would change river elevations at the U.S.-Canada border in the months of December and January, with much steeper drops than the No Action Alternative. MO2 levels would follow the same pattern as the No Action Alternative through April with rising elevations until July, then dropping steeply until September, when they rise again. The No Action Alternative and MO2 levels would then level off about November, but in December MO2 levels would drop quickly, whereas No Action Alternative levels would rise slightly and hold steady for another month and then drop at a lower rate. This would result in decreased habitat and more benthic production becoming dewatered than the No Action Alternative from December through about March 1. This change in elevation drops of 4 feet represents the vertical feet; actual habitat dewatered would depend on the slope of the riverbanks at this elevation. As the river flows downstream closer to Lake Roosevelt, the pattern is the same but the additional drop from MO2 would result in about six feet lower elevation at river mile 720.

In Lake Roosevelt, the production, distribution and persistence of zooplankton is highly variable and sensitive to retention time of water in the reservoir, which is a function if inflows, reservoir volume, and outflows. The longer residence times allow for increased abundance and larger-bodied zooplankton to be more widely distributed throughout the reservoir. Lower retention times result in fewer and smaller-bodied zooplankton that get concentrated near the dam, where they would be subject to high rates of entrainment. Retention time under MO2 would be very similar to MO1; meaning median retention time would be similar to the No Action Alternative in late spring, summer, and fall. Retention time under MO2 would be lower in December through January, but slightly higher in May in most years. In wet years is when retention time is lowest because more water is moving through the system, and MO2 would reduce retention times even further in these years by up to 10 percent in February and by 3 percent to 10 percent in the entire period of December through May. With lower retention times under MO2 in winter and spring, when retention times are already low, there would be less productivity and increased entrainment of zooplankton. The larger, longer-lived species would be disproportionately affected. The elevations in Lake Roosevelt would follow the same pattern as in the river sections described above, with MO2 elevations dropping about 7 feet December 1st rather than staying steady as in the No Action Alternative. This would result in desiccation of more aquatic macroinvertebrates and overall decreased habitat in shallow areas of the reservoir.

Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short retention time and low productivity. Here the macroinvertebrate community consists of production of aquatic insects similar to upstream of Lake Roosevelt, as well as the zooplankton entrained out of Lake Roosevelt. Regarding aquatic insect production and desiccation, river stage at RM 594 in Rufus Woods Lake would follow the same pattern and magnitude changes as the No Action Alternative from April through December. At that time, however, the river stage would rapidly increase about a foot for a short time period and then drop back down to similar to the No Action Alternative. In the month of March, the stage would be slightly lower by about a half of a foot for less than a month. Aquatic macroinvertebrate habitat would be relatively similar to the No Action Alternative most of the year. The temporary increase in December could result in colonization of a small amount of habitat that would then become dewatered and desiccate these invertebrates, as could the minor, temporary decrease in March.

**Region C**

MO2 operations would result in a steep, 34-foot drop in elevation in January through March, while the elevation under the No Action Alternative would stay fairly level at this time. This steep drop would severely decrease benthic habitat and further desiccate any established production. Summer elevations would be similar to the No Action Alternative, with steep drops from July through September. Already low levels of benthic production in Dworshak reservoir would be even further reduced. More extensive variation in water surface elevation, near-shore wave action that causes erosion, and the lack of aquatic plants along the shoreline would further limit production. The summer euphotic zone for zooplankton production would be similar to the No Action Alternative.

In the Clearwater River below Dworshak Reservoir, flows would be about five times higher than the No Action Alternative outflows in January, and then variably lower and higher than the No Action Alternative in February and March. This extreme increase in winter flows would greatly reduce the suitability of benthic habitat in the Clearwater River in winter. Summer flows would be similar to the No Action Alternative, which are also unsuitably high for natural production of macroinvertebrates in a river system.

Conditions in the lower Snake River would be similar to the No Action Alternative. The macroinvertebrate community of the lower Snake reservoirs and river would continue similar to the No Action Alternative. Siberian prawns and opossum shrimp may continue to increase in the reservoir environments. The reservoirs would continue to provide habitat for clams, mussels, etc., as in the No Action Alternative, and crayfish would find ample suitable habitat in the rock and riprap of reservoirs. Soft substrates of the reservoirs would continue to be dominated by low species diversity, mostly worms. Harder substrates would provide habitat for a relatively poor diversity of aquatic insect larvae.

**Region D**

MO2 would result in only minor changes to flows or temperatures that could affect macroinvertebrate communities in the lower Columbia River. Very little benthic macroinvertebrate information is available for the lower Columbia River. Lake habitats in the impounded reaches would continue to support a low diversity of worms, benthic insects, and mollusks. The other run of river dams would continue to be operated at stable elevations that would continue production of these aquatic macroinvertebrates.

**SUMMARY OF EFFECTS**

**Anadromous Fish**

MO2 includes structural measures to improve survival of juvenile salmon and steelhead. However, operational measures such as lower spill and lower spring flows for flood risk management and hydropower would increase travel time and the number of powerhouse encounters for juvenile outmigrants. MO2's spill to near 110 percent TDG decreases the proportion of spill at each of the lower Columbia and lower Snake projects. This reduced spill has the net effect of routing more juvenile salmon and steelhead towards powerhouse routes and less salmon and steelhead through spill routes. Structural measures such as powerhouse surface collectors did not result in sizeable increases in juvenile survival or improvements in adult returns.

TDG exposure levels under MO2 are expected to be similar or slightly reduced compared to the No Action Alternative. Modeled species such as juvenile upper Columbia River spring-run Chinook and upper Columbia River steelhead, are expected to see decreases in survival, increases in travel time, increases in powerhouse passage events, and decreased adult return rates.

The expected effects of MO2 on anadromous species varied depending on the species, location, and by the outputs from the two distinct models (CSS and LCM) used in this analysis. For upper Columbia River Chinook salmon and steelhead, the LCM predicted one to four percent relative reductions in-river survival as well as a one percent relative reduction in the SAR estimate for upper Columbia River spring Chinook.

For Snake River spring Chinook and steelhead, the CSS model generally predicted adverse effects, a 30 percent relative reduction in SARs for spring Chinook, while the LCM generally predicted negligible to minor beneficial effects relative to anadromous species that were modeled in the No Action Alternative. The minor beneficial effects result from increases in transportation rates.

MO2 also includes structural modifications at the dams to benefit passage of adult salmon, steelhead, and Pacific lamprey. While structural modifications may provide some benefit to lamprey passage, the overall shift to more powerhouse flow and passage makes this alternative less effective at meeting the objective to improve conditions for lamprey than the other action alternatives. Greater numbers of lamprey would likely pass near fish bypass screens and would be at a higher risk of injury or impingement compared to the No Action Alternative.

**Resident Fish**

In some regions, MO2 would generally have some key effects similar to the No Action Alternative, with minor to major adverse effects in localized areas. In Region A, discharges from Libby Dam would continue to have detrimental effects to fish species downstream, with lower food production and less habitat. Benthic insect production would be decreased in Region A reservoirs under MO2 due to changes in reservoir operations to provide additional power generation in winter. Reductions in flows would reduce the threat of fish entrainment at certain projects in summer but increases in winter outflows at Hungry Horse would cause a major decrease in bull trout habitat in the Flathead River, as well as increase entrainment of fish and winter food sources. In Region B, changes in elevations and outflows of Lake Roosevelt (Grand Coulee Dam) would result in moderate adverse effects to kokanee, burbot, and redband rainbow trout due to reduced retention times, more severe adfluvial effects limiting access to tributaries, and increased egg desiccation. In Region C, Dworshak Reservoir outflow increases in winter would likely result in major adverse effects due to increases in kokanee entrainment. In the lower Snake River, more flow would be put through the turbines relative to the No Action Alternative; species such as bull trout migrating downstream in the Snake River would see a minor increase in mortality compared to spillway or bypass passage. In Region D, effects in the Lower Columbia River would be minor adverse to negligible.

**Macroinvertebrates**

Changes in operations at projects such as Hungry Horse and Lake Roosevelt would result in winter elevations lower than the No Action Alternative that are drafted faster, resulting in less habitat and aquatic insects. In areas such as the Clearwater River below Dworshak Reservoir, extreme increases in winter flows and variability would greatly reduce the suitability of benthic habitat. Conditions in the lower Snake and Columbia Rivers are expected to be similar to those in the No Action Alternative. Overall, effects are expected to be moderate.

### *3.5.3.6 Multiple Objective Alternative 3*

**ANADROMOUS FISH**

**Salmon and Steelhead**

Several different ESU/DPS units of salmon and steelhead share a similar life cycle and experience similar effects from the MOs, but also have ESU-DPS specific traits that specifically drive effects differently from one another. Common effects analyses across all salmon and steelhead are discussed first, and then those ESU/DPS specific effects are displayed.

***Effects Common Across Salmon and Steelhead***

<u>Summary of Key Effects</u>

MO3 would involve breaching the lower Snake River embankments, which would end juvenile fish transportation at the collector projects, and would have effects on both juvenile outmigration and adult upstream migration.

Upon the breaching of the LSR dams, Bonneville would no longer have an obligation to fund US Fish and Wildlife Service for the operations and maintenance of the LSRCP facilities. Bonneville's funding authority is directly tied to the operation of the LSR dams. The co-lead agencies also recognize that there would be transitional needs that would be addressed in the additional mitigation measures for MO3 discussed in Chapter 5. Additionally, the Bonneville F&W Program funding for offsite mitigation projects in the Snake River Basin, implemented by local, state, tribal, and federal entities, would be reviewed and potentially adjusted. Any changes of this nature would be implemented over time as the effectiveness of dam breaching is observed and would be done in consultation with fish and wildlife managers, regulatory agencies, and the Northwest Power and Conservation Council. Consistent with this, offsite mitigation projects for the other CRS dams would be reviewed and could be adjusted as operations change over time. Proposed project modifications would be coordinated with project sponsors and regional stakeholders to determine appropriate funding levels.

<u>Juvenile Fish Migration/Survival</u>

With the breaching of lower Snake River dams, hatchery mitigation would change, as noted above. Currently, hatchery fish account for 80 to 90 percent of all juvenile Snake River fish passing CRS projects. COMPASS and CSS models do not account for this potential major reduction in juvenile fish production and as noted throughout this chapter, unless otherwise specified, quantitative results from COMPASS, CSS, and the LCM are based on a combination of hatchery and natural origin fish. This applies for both juvenile and adult results. Consequently, qualitative analyses are added to these modeling results.

MO3's spill to 120 percent TDG at the lower Columbia projects increases the proportion of spill at each of the lower Columbia projects. This increased spill at the lower Columbia projects has the net effect of routing more juvenile salmon and steelhead towards spill routes and less salmon and steelhead would pass through powerhouse routes. For juvenile salmon and steelhead, fish modeling was used when available to estimate the effects of these spill changes and dam breach on fish.

Flow patterns in the Lower Columbia River also changed in MO3 relative to the No Action Alternative and these included decreases in monthly average flows of 1 to 3 percent from March to August. Similar to the spill changes, fish modeling was used when available to estimate the effects of these flow changes on juvenile fish. These flow changes were caused by one or a combination of the following operational measures:

- Sliding Scale at Libby and Hungry Horse
- Modified Draft at Libby
- December Libby Target Elevation
- Update System FRM Calculation
- Planned Draft Rate at Grand Coulee
- Grand Coulee Maintenance Operations
- Lake Roosevelt Additional Water Supply
- Hungry Horse Additional Water Supply
- Chief Joseph Dam Project Additional Water Supply

Increasing the operating range by 6 inches John Day Dam relative to the No Action Alternative would slightly increase juvenile fish travel times and exposure to predators (NMFS 2019). Similarly, holding contingency reserves within juvenile fish passage spill is likely to have little effect on juvenile migration. These measures were both included in the 80-year modeling datasets.

Several measures in MO3 are not readily incorporated into modeling for effects analysis, or are modeled but may be difficult to separate from other factors, and so effects of these measures are discussed qualitatively.

As discussed in the analysis for MO1 and MO2, the replacement of existing weirs (top spill or removable) with adjustable spillway weirs would likely allow greater flexibility to address tailrace eddies. This would also allow for longer spillway weir operation under lower flow conditions towards the end of the juvenile spring/summer-run Chinook outmigration.

The removal of fish screens at some dams would reduce in-river survival in the COMPASS model to some degree but would not have an effect on in-river survival in the CSS model. Removing fish screens would shift fish that would have otherwise entered the juvenile bypasses into other routes, likely turbine routes. This measure was included in the modeling datasets.

Operating turbines within and above 1 percent efficiency may or may not affect juvenile Snake River spring/summer-run Chinook direct survival based on studies finding that peak passage survival does not coincide with observed turbine peak operating efficiency (Mathur et al. 2000; Skalski et al. 2002; Deng et al. 2007). A meta-analysis also found no association between relative turbine efficiency at a site and smolt passage survival (Skalski et al. 2002). However, Ferguson et al. (2006) reported spring-run Chinook delayed mortality resulting from operation of McNary Dam turbines outside the 1 percent range; so it is possible that operating outside 1 percent turbine efficiencies at some dams may decrease Snake River spring/summer-run Chinook survival.

The measures intended to improve conditions for lamprey in MO3 are anticipated to have a negligible effect on salmon and steelhead survival.

No juvenile fish would be transported. Overall, MO3 is somewhat similar to the No Action Alternative from a TDG perspective but shows a small reduction in overall TDG exposure.

UW/CBR TDG modeling, separate from COMPASS and CSS in-river survival estimates, estimated juvenile fish median reach average exposure to TDG indices would change depending on dams passed, from a decrease of about 5 percent for Snake River fish to an increase of up to 1 percent for upper Columbia fish relative to the No Action Alternative.

There would be anticipated decrease in fish injury from dam passages under MO3 due to breach of the four lower Snake Dams, installation of improved fish passage turbines at John Day Dam, and higher spill in the lower Columbia, relative to the No Action Alternative, and anticipated concomitant decrease in juvenile predation exposure due to these factors.

Turbidity is anticipated to change under MO3 during the breach phase and years immediately following the breach especially (see Section 3.4, *Water Quality*). The increase in turbidity during these periods is anticipated to reduce predation. Over time, turbidity is likely to reach an equilibrium close to the No Action Alternative and it is unclear how overall predation would change relative to the No Action Alternative. However, the predators that would remain are more likely to be native predators adapted to riverine system and shift away from predators that are well adapted to reservoir habitats. Decreased travel time through the lower Snake River will also reduce juvenile salmon and steelhead predation by birds and fish. The reduced predation risk due to faster travel times and increased turbidity may be offset by some unknown amount due to reduced predator swamping effects stemming from the loss of hatchery fish.

<u>Adult Fish Migration/Survival</u>

Overall, the Bonneville Dam ladder structural measure may reduce delay for adult fish passing under crowded conditions; however adult fallback rates may also increase under MO3 due to higher spill levels at the lower Columbia projects, which could increase adult fish delay (Boggs et al. 2004; Keefer et al. 2005). It is important to note that regional managers use in-season adaptive management to identify and remedy any excessive fallback.

Increasing the reservoir operating range at John Day Dam would have little effect on flow, and thus is not expected to affect adult migration timing or survival rates. Similarly, holding contingency reserves within juvenile fish passage spill would be likely to have little effect, if any, on adult migration.

Several changes affecting migration through the breached section would occur, including: Maximum summer water temperature would increase slightly; water temperature variability would increase; and water temperatures would not stay cool as long into the spring and would cool earlier in the fall with the removal of the thermal inertia of the lower Snake Dam reservoirs. See additional information in Section 3.4, *Water Quality*, and Appendix D.

The breached areas are not expected to delay adult migration because they would be designed to pass fish at flows up to 170,000 cfs, equivalent to a 5-year high-flow event. Flows less than 5 feet per second (ft/s) are not considered to impede adult upstream migration and would require no additional resting structures. All Lower Snake breaches would provide velocities between 2 to 3 ft/s and flow depths around eight feet for total river flows of 15,000 cfs. As river flows increase, so do velocities and flow depths. Typical overbank velocities associated with 170,000 cfs range between 3 ft/s to 8 ft/s with flow depths between 22 and 28 feet. Velocities in the breach area at flows greater than 170,000 cfs could be in ranges that may impede movement even with structures. The high flow periods occur in the spring when spring-run Chinook salmon, sockeye salmon, and some steelhead migrate upstream through the lower Snake River.

In any breached areas where velocities are predicted to be above 5 ft/s at flows less than 170,000 cfs, channel enhancement features would be installed to assist fish in migrating upstream in steps. Where overbank velocities exceed 5 ft/s, channel enhancement features, such as precast 6-foot boulders, would be placed to provide energy dissipation along the bank to provide resting locations. The spacing of these features ranges from about 200 feet at 5 ft/s to 10 feet for 12 ft/s. The location and extent of channel enhancement features would be detailed in future hydraulic modeling efforts.

***Upper Columbia River Salmon and Steelhead***

Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five PUD owned dams and reservoirs, which also impact the survival and passage of these species. The federal agencies do not dictate generation or spill levels at the PUD projects so metrics such as powerhouse encounter rate are not directly affected but are influenced by river flow levels coming through the upper Basin. The timing and volume of flow levels affected by CRS operational decisions are reflected in model analysis. COMPASS and LCM estimates of powerhouse encounter rate and SARs include passage effects from a combination of federal and PUD dam passage (Rock Island Dam to Bonneville Dam). CSS model results are not available for upper Columbia stocks.

<u>Upper Columbia Spring-Run Chinook Salmon</u>

*Summary of Key Effects*

COMPASS modeling estimates that MO3 is expected to result in a 1 percent increase in upper Columbia River Chinook average juvenile survival, an 8 percent decrease in average juvenile travel time, and a 12 percent decrease the number of powerhouse passage events.

*Juvenile Fish Migration/Survival*

CSS cohort modeling for upper Columbia spring-run Chinook was not available for this analysis, but the COMPASS model estimates based on a combination of hatchery and wild fish that MO3 would have the following effects on upper Columbia spring Chinook, compared to the No Action Alternative, described below in Table 3-85:

**Table 3-85. Multiple Objective Alternative 3 Juvenile Model Metrics for Upper Columbia River 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% |

The COMPASS modeling results support initial qualitative expectations that the predicted MO3 survival rates from McNary Dam to Bonneville Dam would increase slightly and travel times would be reduced slightly.

For upper Columbia spring-run Chinook salmon, UW/CBR modeling estimated that the McNary to Bonneville Dam reach-average TDG exposure index would change less than 1 percent in MO3 relative to the No Action Alternative.

*Adult Fish Migration/Survival*

NMFS LCM results were provided for the only extant upper Columbia spring-run Chinook MPG: the North Cascades MPG, using the Wenatchee River population. CSS LCMs for upper Columbia species are not available for this analysis. Based on LCM model predictions, a negligible increase in SARs for upper Columbia Chinook and a variable increase in abundance is estimated based on latent mortality assumptions. See Table 3-86 for details:

**Table 3-86. Model Metrics Related to Adult Survival and Abundance of Upper Columbia River 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% | +.01% | +1% |
| NWFSC LCM abundance range with decreased latent mortality[1] | 498 | 519 (0%)<br>636 (10%)<br>882 (25%)<br>1228 (50%) | +21 (0%)<br>+138 (10%)<br>+384 (25%)<br>+730 (50%) | +4% (0%)<br>+28% (10%)<br>+77% (25%)<br>+147% (50%) |

[1] NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARS or abundance output. For discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent are shown. The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if changes in the alternative were to decrease latent mortality by that much.

Current life-cycle models do not incorporate interactions between populations (straying, source-sink dynamics, etc.) or between MPGs, though these dynamics are generally known to occur. That said, they provide useful frameworks for assessing how populations are likely to respond to factors that are correlated with survival or abundance.

For upper Columbia spring-run Chinook, the (NMFS LCM estimates that MO3 would have the following effects compared to operations under the No Action Alternative:

- No change in smolt to adult (SAR) return rate from, Rock Island to Bonneville (this estimate includes passage past three Public Utility District dams) but large increase in SAR if productivity also increases by 50 to 100 percent (i.e., additional reduction in latent mortality that could be a result of reduced powerhouse encounters in the lower Columbia);
- Upper Columbia spring-run Chinook adult abundance would increase over time with overall small increases in median abundance, but potentially substantial increases across the modeled population if productivity also increases by 50 to 100 percent (i.e., additional reduction in latent mortality).

<u>Upper Columbia River Steelhead</u>

*Summary of Key Effects*

COMPASS modeling estimates that MO3 is expected to result in a less than 1 percent decrease in average juvenile survival for upper Columbia steelhead, a less than 1 percent increase in average juvenile travel time, (roughly 2 hours) and a 7 percent decrease in the number of powerhouse passage events from McNary to Bonneville Dam.

*Juvenile Fish Migration/Survival*

CSS modeling for upper Columbia steelhead was not available for this analysis, but the COMPASS model estimates that MO3 would have the following effects compared to the No Action Alternative, described below in Table 3-87.

**Table 3-87. Multiple Objective Alternative 3 Juvenile Model Metrics for Upper Columbia River 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% |

For upper Columbia River juvenile steelhead, UW/CBR modeling estimated that the McNary to Bonneville Dam reach-average TDG exposure index would increase by about one percent relative to the No Action Alternative.

*Adult Fish Migration/Survival*

No LCM results were provided for the upper Columbia River steelhead DPS, which is composed of a single MPG: the North Cascades MPG. NMFS LCM for steelhead are still in development and not available for this analysis and CSS LCM of MOs was not provided for upper Columbia species.

Upper Columbia River Coho Salmon

See upper Columbia River spring-run Chinook salmon analysis as a surrogate for juvenile upper Columbia coho salmon and upper Columbia fall Chinook salmon analysis as a qualitative surrogate for adult upper Columbia River coho salmon.

*Summary of Key Effects*

The primary challenges for upper Columbia coho salmon are the conditions they encounter during upstream and downstream migrations. Overall, minor increase in survival is anticipated for juvenile upper Columbia coho between McNary and Bonneville dams, based on modeling completed for the surrogate species of upper Columbian River spring-run Chinook juveniles (Table 3-88). CRS operational changes are not likely to affect survival rates for upper Columbia adult coho migrating upriver.

*Juvenile Fish Migration/Survival*

See Upper Columbia River spring run Chinook salmon for estimated, surrogate measures of juvenile survival under MO3 compared to the No Action Alternative. Modeling of surrogate species indicates that juvenile coho survival would have minor increases and that under MO3 could also slightly reduce upper Columbia coho juveniles' susceptibility to predation by other fish and birds of prey based on modeled changes in the number of turbine passages, travel time, and installation of improved fish passage turbines at John Day Dam.

For an overview of juvenile and adult predation generally under MO3, see the Effects Common Across Salmon and Steelhead section, under Section 3.5.3.6.

*Adult Fish Migration/Survival*

See the Effects Common across Salmon and Steelhead section, under Section 3.5.3.6, for an overview of change in adult migration/survival for salmon and steelhead under MO3 relative to the No Action Alternative.

Under MO3, CRS operational changes are not likely to affect survival rates for upper Columbia adult coho migrating upriver. For more information, see surrogate effects analysis of MO3 for *Upper Columbia Fall Chinook*.

<u>Upper Columbia River Sockeye Salmon</u>

Refer to the upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia River sockeye salmon.

*Summary of Key Effects*

The most notable effects for Columbia River sockeye from MO3 are the minor benefits that would occur downstream from the confluence with the Snake River. Breaching of the lower Snake River dams would increase turbidity during breaching and in high water events for some unknown period after the breach. Increased turbidity reduces predation on juvenile salmon from sight feeding predators. In addition, increased abundance of Snake River salmon populations, following dam breach may contribute to Columbia River population survival as larger numbers of outmigrating juveniles may swamp predators. However, the magnitude of these changes is uncertain.

*Juvenile Migration/Survival*

This alternative (MO3) is expected to have small decrease to migration time for juvenile sockeye as measured from Rock Island Dam to Bonneville Dam, and would have a small increase in juvenile survival during their migration period of April 15 to June 15. Modeled river flows during the driest 25 percent of years would be slightly lower, but not a substantial difference from the No Action Alternative.

A minor increase in survival is expected for the upper Columbia River sockeye due to effects of breaching the lower Snake River Dams. These effects would come from the increase in turbidity levels from the Snake River, which may help the survival of smolts as they would be less visible to predators.

Under MO3 there would be displacement of some predators below the confluence of the Snake and Columbia Rivers following breaching until conditions stabilize and populations return to affected areas. Overall, there would be a negligible decrease in risk of sockeye predation by larger fish at the time of breaching, followed by gradual increases in risk of exposure to these predators as the habitat and water quality stabilize.

An increase in colonial waterbird nesting habitat is expected in the area of the lower Ice Harbor pool. Only those islands that would not be inundated in spring flows are suitable habitat. This may increase the local bird population in McNary pool and would affect the rate of predation on Columbia River sockeye.

Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia River sockeye salmon, for additional information in modeled juvenile fish migration and survival metrics.

*Adult Migration/Survival*

The summer water temperatures in the river during the upstream migration would not change. Likewise, TDG and its effects in the form of GBT would have no appreciable difference in MO3 for either adults (or juveniles).

Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia River sockeye salmon, for additional information in modeled adult fish migration and survival metrics.

<u>Upper Columbia River Summer/Fall-Run Chinook Salmon</u>

*Summary of Key Effects*

Overall, no changes are anticipated for juvenile upper Columbia summer/fall-run Chinook. There may be slightly less adult migration delay due to slightly fewer days when water temperatures in the McNary tailrace exceed 20°C, but slightly greater adult migration delay due to slightly higher incidence of adult ladder temperature differentials above 2°C.

*Juvenile Fish Migration/Survival*

No change is anticipated in McNary and John Day Reservoir plankton communities or shoreline habitats under MO3, relative to the No Action Alternative (see Section 3.4, Water Quality, and the Resident Fish subsection of Section 3.5.2.5 for additional information). Likewise, juvenile rearing habitat below Bonneville Dam is not expected to change relative to the No Action

Alternative. Overall, no changes are anticipated for juvenile upper Columbia summer/fall-run Chinook.

*Adult Fish Migration/Survival*

Specific to Okanogan upper Columbia summer/fall-run Chinook, there is no change in number of days the mainstem would be 20°C or higher at the confluence of the Okanogan River, relative to the No Action Alternative. This means that there would be no change anticipated in the ability of the Okanogan fish to hold in the mainstem until temperatures in the Okanogan River are cool enough that adults can move up from the mainstem without having to migrate through water temperatures typically considered lethal for salmon and steelhead (Ashbrook et al. 2009).

The frequency of meeting the Vernita Bar Agreement to protect the prolific fall-run Chinook spawning in and around the Hanford Reach of the Columbia River in Washington is not expected to change under any MOs relative to the No Action Alternative. Other operational changes under MOs are likewise not anticipated to affect upper Columbia summer/fall-run Chinook spawning from the tailrace of Chief Joseph Dam to Bonneville Dam in terms of changes in flows, water temperatures, or TDG generated under the MOs.

***Middle Columbia River Salmon and Steelhead***

<u>Middle Columbia River Spring-Run Chinook Salmon</u>

See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River Spring-Run Chinook Salmon.

*Summary of Key Effects*

CRS operational changes under MO3 will result in increased survival, faster travel times, and decreased powerhouse passage events on juvenile middle Columbia River Chinook salmon. These effects would lead to negligible to minor benefits to Middle Columbia River Spring Chinook.

*Juvenile Fish Migration/Survival*

See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River Spring-Run Chinook Salmon.

*Adult Fish Migration/Survival*

See upper Columbia River spring-run Chinook salmon analysis as a surrogate for adult migration and survival of middle Columbia River spring-run Chinook salmon.

<u>Middle Columbia River Steelhead</u>

Refer to Upper Columbia River steelhead analysis as a surrogate for Middle Columbia River steelhead.

*Summary of Key Effects*

Juvenile and adult middle Columbia River Steelhead would be exposed to moderate increases in TDG. Other effects to juvenile fish would be similar to those experienced by Upper Columbia steelhead. Adult middle Columbia River steelhead would experience minor increases in fallback rates, but kelts would also experience minor increases in survival.

*Juvenile Fish Migration/Survival*

Populations of middle Columbia River steelhead distributed between the Deschutes and Walla Walla Rivers pass two to four dams in the lower Columbia on their downstream outmigration to the ocean. COMPASS modeling for juvenile upper Columbia River steelhead was used as a surrogate for middle Columbia River steelhead. Under MO3, juvenile survival, travel time and powerhouse encounters would both have a small decrease from the No Action Alternative. However, these fish would experience a moderate increase in elevated TDG. Refer to upper Columbia River steelhead analysis as a surrogate for middle Columbia River steelhead for additional information.

*Adult Fish Migration/Survival*

Under MO3, higher spill levels at the lower Columbia projects during spring outmigration would result in minor increases in fallback rates. However, there would also be minor increases in survival of kelts as they migrate downstream because fewer adults would pass through the powerhouse (Normandeau et al. 2014). There would also be moderate increases in TDG under MO3 compared to the No Action Alternative. Refer to upper Columbia River steelhead analysis as a surrogate for middle Columbia River steelhead for additional information.

***Snake River Salmon and Steelhead***

<u>Snake River Spring/Summer-Run Chinook Salmon</u>

*Summary of Key Effects*

COMPASS and CSS modeling results indicate that survival rates would increase and travel times would decrease (fish would migrate downstream faster). However, the potential reduction of hatchery fish noted in the common effects analysis may reduce numbers of juvenile Snake River Chinook salmon by as much as 85 percent. This reduction would potentially result in lower survival rates of wild Chinook as they navigate through the predators inhabiting the migratory corridor. The model estimates for both CSS and LCM presented in this section are based on a combination of hatchery and wild fish. The CSS model was able to produce similar estimates using wild fish only, but because those estimates still assume that hatchery fish are present and migrating along with the natural origin fish, they do not represent an estimate of a wild fish only migration such as may occur if hatchery production was reduced or eliminated post-dam breach. The CSS wild fish estimates are presented in memo form (See appendix E) for reference.

*Juvenile Fish Migration/Survival*

For Snake River spring/summer-run Chinook salmon, the COMPASS and CSS models estimate that MO3 would have the following effects compared to operations under the No Action Alternative, described below in Table 3-88. As noted above, the model estimates in Table 3-89 were developed with a combination of hatchery and natural origin fish data. COMPASS results reflect data obtained from the Salmon River wild and hatchery combined estimates.

**Table 3-88. Multiple Objective Alternative 3 Juvenile Model Metrics for Snake River 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% |

The COMPASS and CSS modeling results indicate that survival rates would increase by as much as 25 percent and travel times would decrease by nearly 30 percent (resulting in fish moving faster through the current hydrosystem) relative to the No Action Alternative. However, reductions in hatchery fish could reduce numbers of juvenile Snake River Chinook salmon by as much as 85 percent. This reduction in the number of hatchery fish would likely result in a reduction of these predicted survival rates of wild Chinook because of increased predation rates. The dam breach measures in MO3 would eliminate the transportation program for juvenile Snake River spring/summer-run Chinook.

For Snake River spring/summer-run Chinook salmon, UW/CBR TDG modeling estimated that the Lower Granite to Bonneville reach-average TDG exposure index would decrease by about 5 percent in MO3.

### *Adult Fish Migration/Survival*

**Table 3-89. Multiple Objective Alternative 3 Adult Model Metrics for Snake River 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%)<br>1.1% (10%)<br>1.2% (25%)<br>1.5% (50%) | +0.12% (0%)<br>+0.12% (10%)<br>+0.36% (25%)<br>+0.61% (50%) | +14% (0%)<br>+25% (10%)<br>+42% (25%)<br>+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%)<br>1951 (10%)<br>2345 (25%)<br>3160 (50%) | +132 (0%)<br>+424 (10%)<br>+818 (25%)<br>+1633 (50%) | +9% (0%)<br>+28% (10%)<br>+54% (25%)<br>+107% (50%) |
| Abundance (CSS)[2/] | 6114 | 14055 | +7941 | +103% |

1/ NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARS or abundance output. For discussion purposes, potential decreases in latent mortality of 10 percent, 25 percent, and 50 percent are shown. The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if changes in the alternative were to decrease latent mortality by that much.

2/ CSS provided results for six populations in the Grande Ronde/Imnaha Major Population Group. The absolute values represent those populations only; the percent change is considered indicative of the Snake River ESU for the purpose of comparing between MOs.

For Snake River spring/summer-run Chinook salmon, the NMFS LCMs and CSS LCM indicate that MO3 may result in a wide range of predicted increases to SAR rates. CSS predicts SARs from Lower Granite to Lower Granite would increase by about 170 percent relative to the No Action Alternative. The NMFS Life Cycle Model predicts relative increases in Lower Granite to Bonneville SARs that range from 14 percent to 70 percent depending on the magnitude of potential reductions in latent mortality.

The NWFSC LCM results generally indicate high variability in potential fish response to dam breach depending on the breach scenario input dataset used for calibration. The CSS LCM results generally indicate that MO3 adult abundance over time would show substantial increases from the No Action Alternative.

Several structural measures in MO3 are anticipated to benefit adult Snake River spring/summer-run Chinook passage upstream and these include modifying the upper ladder serpentine sections at Bonneville Dam (reducing migration delay). Overall, as with the other MOs, neither CSS nor the LCM indicates that powerhouse surface passage structures in MO3 would have a substantial effect on adult abundance over a 30-year period.

Fallback rates of Snake River spring/summer-run Chinook at the lower Columbia dams may increase under MO3 since fallback for this ESU has been associated with higher flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). In those studies, fish that fell back were less likely to reach their spawning areas compared to fish that never fell back. For example, of the 11 percent of Snake River spring- summer Chinook that fell back at Bonneville dam nearly 14 percent failed to reascend (Boggs et al. 2004). Thus, the MO3 higher spill operation may result in a small increase in the fallback of Snake River spring/summer-run Chinook salmon adults as they migrate upstream. It is important to note that regional managers use in-season adaptive management to identify and remedy any excessive fallback. So while the average survival for Snake River spring/summer-run Chinook salmon adults may decrease slightly from the recent averages of about 89 percent in the Bonneville to McNary Dam reach under the No Action Alternative, increased fallback is not anticipated to have a large effect under this alternative.

Spill cessation starting August 1 at the lower Columbia River dams would likely have negligible effects on summer migrating adults (fallback-related effects) and no effects on spring migrating adults. While fallback rates may be lower, individuals that fell back would experience greater risk of falling back through turbines and juvenile bypass systems compared to spillways once the spill cessation trigger is met at individual lower Snake projects. Adult migration through the breached lower Snake segment is discussed in the following section.

Increasing the reservoir operating range at John Day Dam would have little effect on flow, and thus is not expected to affect adult migration timing or survival. Similarly, holding contingency reserves within juvenile fish passage spill would have negligible effects on adult migration.

Collectively, the water management measures and water supply measures in MO3 would have negligible effects to Snake River spring/summer-run Chinook.

Several changes would occur affecting migration through the breached section, including the following: Maximum summer water temperature would increase slightly; water temperature variability would increase; and water temperatures would not stay cool as long into the spring and would cool earlier in the fall with the removal of the thermal inertia of the lower Snake dam reservoirs. See additional information in Section 3.4, Water Quality, and Appendix D.

The breached areas are not expected to delay adult migration because they would be designed to pass fish at flows up to 170,000 cfs, equivalent to a five-year high flow event. Flows less than this rate are not considered to impede adult upstream migration and would require no additional resting structures. All Lower Snake breach locations provide velocities between 2 to 3 feet per second and flow depths around eight feet for total river flows of 15,000 cfs. As total river flows increase, so do velocities and flow depths. While velocities in the breach area at flows greater than 170,000 cfs could be in ranges that may impede movement even with structures, upstream migration does not occur during these high flows. The high flow periods occur in the spring when spring-run Chinook salmon, sockeye salmon, and some steelhead migrate upstream through the lower Snake River.

In any breached areas where velocities are predicted to be above 5 ft/s at flows less than 170,000 cfs, channel enhancement features would be installed to assist fish in migrating upstream in steps. Where overbank velocities exceed 5 ft/s, channel enhancement features such as precast 6-foot boulders would be placed to provide energy dissipation along the bank to provide resting locations. The spacing of these features ranges from about 200 feet at 5 ft/s to 10 feet for 12 ft/s. The location and extent of channel enhancement features would be detailed in future hydraulic modeling efforts.

Snake River Steelhead

*Summary of Key Effects*

Quantitative model estimates show that MO3 may result in higher juvenile Snake River steelhead survival, reduced travel times and decreased powerhouse passage events. Because the lower Snake projects would be breached, juvenile fish transportation would be eliminated. Steelhead kelts and overwintering steelhead moving downstream in the breached section of the Snake should also experience higher survival rates and faster travel times. The model estimates for both CSS and COMPASS presented in this section are based on a combination of hatchery and wild fish. The CSS model also produced similar estimates using wild fish only; but because those estimates still assume that hatchery fish are present and migrating concurrently with the natural origin fish, those estimates are not representative of a wild fish only migration. This does not capture what would occur if Lower Snake River Compensation hatchery production was reduced or eliminated post-dam breach. The wild fish specific estimates from CSS are contained in Appendix E for reference.

*Juvenile Fish Migration/Survival*

For Snake River steelhead, the COMPASS and CSS models estimate that MO3 would increase juvenile survival and reduce travel time, elevated TDG, and powerhouse encounters (Table 3-90).

**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% |

The COMPASS and CSS modeling results indicate that survival rates would increase between 23 and 46 percent relative to the No Action Alternative and that travel times would decrease between 32 and 45 percent relative to the No Action Alternative. However, potential reductions of hatchery fish may also reduce numbers of juvenile Snake River steelhead as discussed above for Chinook salmon. This potential reduction in the number of hatchery fish would likely result in a reduction of these predicted survival rates of steelhead because of increased predation rates since the two stocks currently migrate downstream together. The dam breach measures in MO3 would eliminate juvenile Snake River steelhead transportation.

For Snake River steelhead, the UW/CBR TDG modeling estimated that the Lower Granite to Bonneville Dam reach-average TDG exposure index would decrease by about 5 percent.

*Adult Fish Migration/Survival*

For Snake River steelhead, the CSS cohort model estimates that MO3 would produce a substantial increase (178 percent) in SAR relative to the No Action Alternative. The CSS model estimated an absolute SAR of 5.0 percent. There are no LCM model estimates available for this DPS (Table 3-91).

**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% |

Higher spill levels at the lower Columbia projects during April should result in higher survival rates for adult Snake River steelhead falling back through dams and kelts migrating downstream. Fewer adults use powerhouse passage routes when a spill route is available and overall downstream passage increased when surface passage was available (Normandeau et al. 2014; Ham et al. 2012).

Steelhead kelts and overwintering steelhead moving downstream in the breached section of the Snake River should experience both higher survival rates and faster travel speeds. It is challenging to estimate additional mortality rates due to dam passage for kelts compared to a free-flowing river environment because mortality is naturally high following spawning. Keefer et al. (2017) used radio telemetry to estimate survival and travel speeds of adult steelhead upstream to spawning tributaries in the Snake River, and the return migration to the ocean. Approximately 85 percent of steelhead died after reaching their natal tributary but before initiating the kelt migration through the hydrosystem. Outmigration survival was a minimum of 31 to 39 percent past the four lower Snake dams and a minimum of 13 to 20 percent past all eight dams. English et al. (2006) compared kelt migration speeds through the middle Columbia and four undammed rivers in British Columbia and found travel speed for kelts was substantially faster in the free-flowing rivers however, water velocity and gradient were not closely correlated with fish travel time.

<u>Snake River Coho Salmon</u>

See Snake River spring/summer-run Chinook salmon as a surrogate for juvenile Snake River coho salmon and Snake River fall-run Chinook as a surrogate for adult Snake River coho salmon.

*Summary of Key Effects*

Overall, MO3 would reduce juvenile coho salmon travel time, powerhouse encounters, and TDG while increasing juvenile survival.

*Juvenile Fish Migration/Survival*

See Snake River spring/summer-run Chinook salmon as a surrogate for juvenile Snake River coho salmon.

*Adult Fish Migration/Survival*

Long-term effects of MO3 on Snake River adult coho would include a lower risk of delay and fallback because four of the dams would be breached. Temperatures would be reduced during adult migration with the total number of days where temperatures are over 20°C at Ice Harbor Dam. Susceptibility to disease would also diminish with lower migration temperatures. All of these effects would improve long-term survival and spawning success of Snake River coho salmon.

Short-term effects under this alternative include elevated suspended sediments and depleted DO levels during breaching that if not mitigated could lead to major losses of adult coho salmon.

<u>Snake River Sockeye Salmon</u>

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Snake River sockeye salmon.

*Summary of Key Effects*

Key long-term effects of MO3 would improve downstream and upstream migration survival through the lower Snake River due to breaching the four dams. Benefits would accrue through faster downstream travel time, fewer powerhouse encounters, lower predation, and reduced TDG effects.

Significant short-term effects could occur due to the large amount of suspended sediment and reduced DO due to breaching the dams. There would be the potential for large-scale mortality for any fish in the river during this construction work.

*Juvenile Migration/Survival*

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake River sockeye salmon.

*Adult Migration/Survival*

The percent of days over 18°C between June 21 and July 31 would be 87.3 percent, which is three additional days over 18°C compared to the No Action Alternative. This means Snake River sockeye might have slightly greater thermal stress than under the No Action Alternative. However, breaching of the four lower Snake River dams is expected to reduce delays in upstream migration and decrease the time fish are exposed to the slightly warmer water temperatures. Additionally, sockeye would not have the transportation effects that can increase straying and fallback and prolong their exposure to thermal stress.

MO3 would eliminate temperature differences between the river and the fish ladders at the dam locations. In addition, breaching the four lower Snake River dams would result in moderate decreases in elevated TDG in the Snake River compared to the No Action Alternative.

Another water quality parameter important during upstream migration is the amount of suspended sediment in the water. The typical sediment load is around 2 mg/L of total suspended solids. Excavation for the dam breach measure of MO3 would cause a large sediment plume each year and potentially during runoff of the following 2 to 7 years. The estimates are nearly 25,000 mg/L during excavation for each breach and 30 mg/L after breach. Approximately 27 days would have suspended sediment over 5,000 mg/L. In the conceptual design proposed for analysis, the timing of dam breaching would occur at the tail end of the adult sockeye migration through the lower Snake River. Therefore, only the latest few fish in the run for two consecutive years of construction would experience the high turbidity levels in the river. The estimated severity of the sediment pulse indicates mortality between 20 and 40 percent of fish downstream of these dams. However, the vast majority of Snake River sockeye would have passed upstream from the dams by the time these levels are reached; therefore, MO3 would have minor increases in mortality of these fish compared to the No Action Alternative.

Under MO3, breaching the four Lower Snake River dams would cause DO levels to drop to approximately 2 mg/L throughout the Little Goose and Lower Monumental pool areas in the year of construction. Sockeye salmon need around 5 mg/L of DO for survival. Sockeye salmon become stressed at lower levels and can suffocate with prolonged lack of oxygen. There may be some loss of late migrating sockeye in these two pools during the peak of sediment release, which is the primary cause of the drop in DO in the water; however, almost all of the adult sockeye would have already passed upstream prior to construction.

Under MO3, the lack of juvenile transportation would reduce the fallback and straying. Straying may still occur but would be at the natural levels for this population. This would improve homing compared to the No Action Alternative and would reduce risk of incidental catch in the middle Columbia River fisheries. Reductions in delay, fallback, and straying are likely under MO3.

<u>Snake River Fall-Run Chinook Salmon</u>

*Summary of Key Effects*

Key long-term effects of MO3 for fall-run Chinook would be the major increase in available spawning habitat. Other major improvements would include the downstream migration survival through the lower Snake River due to breaching the four dams. Benefits would accrue through faster downstream travel time, fewer powerhouse encounters, substantially less predation, and reduced TDG.

Major short-term effects would occur due to the large amount of suspended sediment during dam breaching. There is the potential for large-scale mortality for any fish in the river during this construction work.

*Larval Development/Juvenile rearing*

Breaching the four lower Snake River Dams is estimated to increase the available spawning habitat for fall-run Chinook from 226 acres to 3,521 acres, an increase of 15 times the area available today (Corps 2002). The mean depth of water would be reduced, but fall-run Chinook use a wide range of depths for spawning and would be expected to take advantage of the new area available due to dam breaching. MO3 would lead to large increases in spawning habitat and improved conditions for spawning.

Under MO3, juvenile fall-run Chinook may move downstream to use McNary and John Day reservoirs for rearing. One of the long-term effects is that the portion of the fish that overwinter in reservoirs for their first year is expected to be smaller in MO3 compared to the No Action Alternative.

*Juvenile Migration/Survival*

The mean water temperature for May through July is estimated to be slightly warmer than in the No Action Alternative with a higher percentage of days over 20°C (35.6 percent in MO3 compared to 26.6 percent in the No Action Alternative). This represents a minor increase in temperatures and days over 20°C compared with the No Action Alternative. However, the cold water flow augmentation from Dworshak is expected to be more effective with the smaller cross-sectional breached areas to cool down in July and August compared to the No Action Alternative. Major decreases in travel times would substantially reduce predation risk.

An increase in nesting habitat is expected in lower Ice Harbor pool area after dam breaching. Only those islands that would not be inundated in spring flows are suitable habitat. Although a small area of nesting habitat may increase, the risk of bird predation would likely decrease as outmigrating Chinook travel times decrease and turbidity increases under MO3; these factors would reduce exposure to bird predators.

One of the long-term effects of dam breaching is a higher sediment load through the free-flowing reach of river. Under MO3, the Snake River is expected to carry approximately 30 mg/L on average. Outmigrating fall-run Chinook would experience a minor decrease in predation risk under MO3 because of the decreased visibility for the predators.

*Adult Migration/Survival*

The dam breach measure of MO3 would reduce the delays to migration caused by temperature differential between the river and the ladders. This would be a benefit to upstream migrating fall-run Chinook.

Temperatures at Ice Harbor would experience a moderate decrease with only 29.2 percent of all adult migration days over 20°C compared to 54.3 percent in the No Action Alternative. Straying and migration delays, as well as susceptibility to disease, would be reduced in MO3. All of these effects would improve survival and spawning success.

Based on sediment movement analysis (see Section 3.3), excavation for the dam breach measure of MO3 would cause a large sediment plume for a long duration, that may reoccur for two to seven years after excavation. In the conceptual design proposed for analysis, the timing of dam breaching would occur during the adult fall-run Chinook migration through the Lower Snake River. Two consecutive years of construction would cause fish in this population to experience the high turbidity levels in the river. The estimated severity of the sediment pulse indicates the potential for mortality between 20 and 40 percent of fish downstream of these dams. This could result in a major short-term loss to the population, but the Snake River fall-run Chinook population would be expected to recover due to the benefits from dam breaching. Further design and mitigation measures would be developed to minimize the short-term losses.

Under MO3, breaching the four Lower Snake River dams and elevated suspended sediments is estimated to cause DO levels to drop to approximately 2 mg/L throughout the Little Goose and Lower Monumental pool areas in the year of construction. Chinook salmon need over 5 mg/L of DO for survival; they become stressed at levels below this and can suffocate with prolonged lack of oxygen. If not mitigated, these levels of DO could cause the loss of major portions of migrating adult fall-run Chinook in these two pools during the peak of sediment release.

MO3 would eliminate juvenile fish transportation. Scientists expect reductions in delay, fallback, and straying under MO3.

***Lower Columbia River Salmon and Steelhead***

<u>Lower Columbia River Chinook Salmon</u>

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower Columbia River Chinook salmon.

*Summary of Key Effects*

Juvenile survival and travel time would be similar to the No Action Alternative under MO3, with the possible exception that the fall run of Lower Columbia River Chinook salmon, which could experience higher outmigration survival through Bonneville Dam with lower spill in August.

Adult migration and survival would be lower for spring-run fish due to increased spill and TDG, while fall-run fish may experience less fallback and delay. Dam breach measures in MO3 would not affect Lower Columbia River Chinook salmon.

*Juvenile Fish Migration/Survival*

Five of the 32 populations of Lower Columbia River Chinook salmon pass Bonneville Dam on their downstream outmigration to the ocean. Modeling was not available for this ESU; however, juvenile survival at Bonneville Dam of Snake River spring/summer-run Chinook salmon was used as a surrogate. COMPASS modeling predicts juvenile survival would have negligible increases (+0.4 percent) higher than the No Action Alternative. Much lower spill at Bonneville in August could have a minor increase in juvenile survival for fall-run Lower Columbia Chinook as powerhouse passage at powerhouse number one has a higher survival than spillway routes.

Effects of outflows from March through September for all runs of Lower Columbia River Chinook salmon would be similar to the No Action Alternative. At The Dalles, water quality modeling indicates higher TDG in April through June with increased spill above the threshold of 120 percent TDG for 76 days, compared to 33 under the No Action Alternative. The small proportion of this ESU that passes above Bonneville Dam may experience increased incidence of GBT during outmigration (spring-run and late-fall-run) and rearing (all runs) between The Dalles and Bonneville. Reduction of spill in August would reduce TDG to levels well below the No Action Alternative levels at this time; fall-run fish outmigrating at this time would not be affected, though they would experience the increased TDG during juvenile rearing. Below Bonneville Dam, modeling indicates the TDG would be slightly higher in the spring and considerably lower in August than the No Action Alternative, with 68 days exceeding the water quality standard compared to 61 days in the No Action Alternative.

*Adult Fish Migration/Survival*

Structural measures such as modifying the upper ladder serpentine sections at Bonneville Dam are expected to reduce delay associated with upstream passage. Fallback rates may decrease for fall-run and late-fall-run fish with decreased spill in August, but increase for spring-run adults. Similarly, TDG would be higher in April through June, but lower in August, so adult spring-run fish would also experience higher TDG exposure. All runs would experience higher TDG exposure for juvenile rearing. Hydrology and water quality modeling predicts flows and temperatures that could affect lower Columbia River Chinook salmon adult migration and survival would be similar to the No Action Alternative.

<u>Lower Columbia River Steelhead</u>

Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

*Summary of Key Effects*

Juvenile survival in MO3 would be similar to the No Action Alternative, with modeled dam survival similar to the No Action Alternative. Faster travel times with higher spill would be expected for fish that pass Bonneville Dam, but reduced flows would also slow travel time for other Lower Columbia River steelhead and potential increased TDG effects. Adult migration of a portion of the winter run could be decreased slightly with higher winter flows. Survival of kelts would be higher in spring and early summer, but lower in winter with reduced spill, and increase TDG may affect adults.

*Juvenile Fish Migration/Survival*

Modeling for juvenile Snake River steelhead was used as a surrogate of juvenile survival for Lower Columbia steelhead that pass Bonneville Dam. These results predict there would be no discernable difference in juvenile survival between MO3 and the No Action Alternative. TDG exposure to the fish that pass upstream of Bonneville would be higher with 43 more days above the water quality standard, and below Bonneville they would experience seven more days over the standard.

*Adult Fish Migration/Survival*

Structural measures such as modifying the upper ladder serpentine sections at Bonneville Dam are expected to have minor reductions in delay associated with upstream passage. Under MO3, higher spill levels during May could increase fallback and delay of a portion of winter-run steelhead. Spill reduction in August would generally reduce adult fallback and delay. Temperatures would be similar to the No Action Alternative, and adult fish would generally experience higher TDG as described for juveniles.

<u>Lower Columbia River Coho Salmon</u>

See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult Lower Columbia River coho salmon.

*Summary of Key Effects*

Lower Columbia River coho salmon would have minor increases in juvenile survival and negligible impacts to adult salmon upstream migration under MO3, relative to the No Action Alternative.

*Juvenile Fish Migration/Survival*

Using the surrogate approach, CRS operational changes in MO3 may slightly increase survival rates for Lower Columbia River juvenile coho passing Bonneville Dam by as much as 1 percent. Refer to Snake River spring-run Chinook for surrogate information in Section 3.5.2.5.

*Adult Fish Migration/Survival*

Upstream migration and survival of adult Lower Columbia River coho salmon would have negligible impacts under MO3 compared to the No Action Alternative using surrogate information. Refer to Snake River fall-run Chinook for surrogate information in Section 3.5.2.5.

Lower Columbia River Chum Salmon

Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia River chum salmon.

*Summary of Key Effects*

MO3 is expected to result in minor increases in juvenile chum survival through Bonneville Dam and Reservoir relative to the No Action Alternative, while incubating chum sac fry would be exposed to minor increases in TDG.

*Juvenile Fish Migration/Survival*

As there is no direct estimate of Bonneville Dam survival specific to juvenile chum, juvenile Snake River spring-run Chinook are used as a surrogate. Under MO3, COMPASS modeling indicates that CRS operational changes are expected to result in minor increases in juvenile chum survival relative to the No Action Alternative. There is no dam-specific survival estimate available from CSS.

Under MO3, chum flow operations would be met slightly more often (1 percent more) than the No Action Alternative. In years when additional releases from Grand Coulee for chum would be needed, the average additional volume needed would be 0.08 Maf.

Maintaining TDG levels of 105 percent or less from November 1 to April 30 appears to provide a sufficient level of protection to chum salmon eggs and sac fry incubating in the gravel downstream of Bonneville Dam in the Ives/Pierce Island Complex, using 3 percent per foot depth compensation. In the No Action Alternative, chum sac fry are exposed to TDG above 105 percent in 4 out of 80 years and those exceedances are all in the mid- to late April timeframe.

*Adult Fish Migration/Survival*

Most chum spawn downstream of Bonneville. Migration of chum into the Columbia River is in October and November. Adult migration and survival under MO3 would likely be similar to the No Action Alternative.

**Other Anadromous Fish**

***Pacific Eulachon***

Summary of Key Effects

Eulachon would continue to migrate into the Columbia River from November through March, with specific dates of migration and spawning based on a variety of environmental factors including temperature, high tides, and ocean conditions (NMFS 2017). Modeled data for MO3 (based on the period of record for Bonneville tailwater temperatures) indicate that temperatures would not be substantially different from the No Action Alternative. Average monthly temperatures in the winter months would be about 0.2 to 0.3 degree Fahrenheit cooler. Spawning locations and substrate conditions would not be expected to differ from the No Action Alternative.

Compared to the No Action Alternative, MO3 would have no change in the time between the peak spawning runs, egg development, and larval emergence. The spring freshet that disperses larvae to adequate food sources would continue to be highly variable, with an average of 166 days between spawning temperature triggers and peak flows (158 days in high flow years, and 157 days in low flow years).

Spring flow rates would be expected to be about 1 percent to 2 percent lower during outmigration compared to the No Action Alternative. Decreased flow can affect the chemical and physical processes of the estuary-plume environment, which affects primary productivity (NMFS 2017). The relationship between Bonneville outflow and the estuary plume is not certain, but a reduction could result in slightly less distribution of larvae.

Bird predation risk can be influenced by flow rates. Higher flows are linked to higher predation rates on eulachon, whereas at lower flows birds tend to switch to marine prey. Under MO3, there would be relatively little change (1 to 4 percent) in all months and water year types (the change is low enough to be likely immeasurable). Slightly higher flows in December could increase predation risk. The early portion of the eulachon run comes in during November and December and may be more subject to predation

Operation of the CRS system under MO3 would result in very similar turbidity levels in spring.

***Green Sturgeon***

Summary of Key Effects

The Columbia River use by green sturgeon is primarily foraging habitat for adults and subadults. Key effects of MO3 are focused on how flows and temperatures influence the cues for entering the Columbia River as well as the availability and distribution of food sources. Overall, the estuary would continue to provide good foraging and rearing habitat for green sturgeon, but there could be a minor decrease in summer foraging habitat under MO3 compared to the No Action Alternative.

Adult Fish Migration/Survival

Green sturgeon migrate seasonally along the West Coast, foraging in bays and estuaries during the summer and fall months, including the Columbia River estuary (as far upstream as Longview). Both southern DPS and northern DPS occur in the Columbia River, but the majority are southern DPS. The Columbia River estuary provides important foraging and rearing habitat for green sturgeon. MO3

Under MO3, green sturgeon would continue to arrive in June and leave in September or October (variation compared to the No Action Alternative is one day or less in arrival/departure date). This date range would be expected to continue supporting adequate rearing conditions.

Under MO3, there could be a slight decrease in summer flows (1 percent to 3 percent from June through September), but overall the estuary would continue to provide good foraging habitat for green sturgeon, but there could be a minor decrease in summer foraging habitat under MO3 compared to the No Action Alternative.

***Pacific Lamprey***

Summary of Key Effects

MO3 has several measures that are designed specifically to benefit lamprey. These measures are proposed structural improvements that include changing extended-length submersible bar screens, expanding the network of Lamprey Passage Structures, changing the design for turbine cooling water strainers, replacing turbines for safer fish passage, to reduce fish injury and mortality.

As described for the No Action Alternative, upstream and downstream passage at the mainstem Columbia River and Snake River dams has been the greatest influence on population decline and reduced distribution of Pacific lamprey. The most substantial benefit of MO3 would be the breaching of the four Lower Snake River Dams. This would reduce mortality to lamprey during the downstream migration phase and would substantially improve the ease of upstream migration. Other key benefits would accrue through the improvements to get fish to enter the fish ladders this would occur through expanding the network of Lamprey Passage Structures and modifying fish ladders to incorporate lamprey passage criteria into the structural modifications.

Larval Development/Juvenile Rearing

MO3 has no measures that would either benefit or harm juvenile lamprey during the rearing stage. All ramping rates and dewatering issues would be the same in MO3 as for the No Action Alternative.

Juvenile Fish Migration/Survival

Under MO3, several structural measures would improve passage conditions, increase survival, and reduce injuries. Proposed actions include the following:

- Changing the extended-length submersible bar screens to a screen material that would substantially reduce mortality due to impingement.
- A new design of structure for exclusion of juvenile lamprey from cooling water strainer intakes would reduce or eliminate this pathway of mortality.
- Additional powerhouse surface passage at McNary projects to change the dynamics of lamprey passage. A higher percentage of lamprey would be expected to pass via the safer surface routes instead of the turbines in relation to the No Action Alternative.
- Replacing turbines at John Day Project with improved fish passage turbines that would improve conditions for fish passage and increase lamprey survival.

Because of the high degree of uncertainty surrounding how many juvenile lamprey are lost or injured on their downstream migration, it is difficult to quantify the improvement represented by all of the measures. For fish that encounter multiple dams on their migration downstream, reducing the total number of hazards would increase their probability for survival.

Adult Fish Migration/Survival

Each structural measure in MO3 that targets lamprey is intended to increase their dam passage efficiency either by getting fish to enter rather than turn back from the fishway, or to increase successful upstream passage. Effectiveness of the measure would vary by dam.

The most substantial benefit from MO3 would occur in the Snake River basin with breaching of the four Lower Snake River Dams. In the proposed conceptual-level designs, the river would run through the excavated earthen embankments and become free flowing in which lamprey could migrate upstream without encountering ladders or other barriers. However, hydraulic analysis shows that high velocity barriers could form at the concrete corners of the abandoned dams during high flows and early season migrants could see velocities above their burst speeds. Substrate along each of the breaches would be riprap to prevent erosion and lamprey would be expected to use burst-speed swimming over riprap.

Breaching of the four lower Snake River Dams would result in faster heating and cooling of river water compared to what would occur in reservoirs in the No Action Alternative. This means the water would be warmer in early June and July, but cooler in August and September.

Fluctuations would occur on diel basis (i.e., water temperatures warm up through the day and cool down at night). The fish would experience cooling in the evenings, which would lessen the overall impact to lamprey. Exposure may be reduced with faster migration times from dam breaches. July temperatures are highest when lamprey peak migrations occur.

Approximately 44 percent of adult lamprey that reach Bonneville Dam pass to upstream areas, while 68 percent of those that pass Bonneville Dam will also pass The Dalles Dam (Keefer et al. 2012). If the proposed structural measures were implemented at Bonneville, moderate improvements in fish passage efficiency would occur. Similar improvements at John Day ladders to improve lamprey entrance into the fishway resulted in increased passage efficiency from 46 percent to 83 percent (Clabough et al. 2015). Because dynamics at each dam are very different, the improvements from the increased passage efficiency cannot be directly inferred across projects, but lamprey would see improvements in overall dam passage efficiency with improvements in ladder entrance efficiency.

At John Day, lamprey passage was estimated at 67.5 percent (Keefer et al. 2019). Additional work for the Lamprey Passage Structures on the south fishway and extension on the north fishway would continue to moderately improve overall dam passage efficiency incrementally.

The overall expected improvements in lamprey passage efficiency should decrease susceptibility to physical stress and mortality. These structural measures for lamprey are expected to provide a major benefit to the population size and distribution of Pacific lamprey in the Columbia Basin, and especially in the Snake River Basin due to breaching of the four lower Snake River Dams.

#### ***American Shad***

Summary of Key Effects

No long-term change is anticipated to juvenile shad in the lower Columbia because plankton communities and shoreline habitat are not changing in the lower Columbia in MO3. The lack of reservoirs in the lower Snake reach would make that reach less suitable for shad than under the No Action Alternative, so an overall decrease in shad under MO3 is anticipated.

Juvenile Fish Migration/Survival

Plankton communities and shoreline habitat are not expected to change in the lower Columbia reservoirs relative to the No Action Alternative. However, plankton communities may be depressed in the lower Columbia reservoirs after the lower Snake dam breaches until a new plankton community equilibrium is established. During the period when plankton communities are depressed, juvenile shad are likely to face minor food reductions and may decline because their diet is almost exclusively plankton.

Adult Fish Migration/Survival

The proportion of adult shad counted at Bonneville Dam that migrate upstream past McNary Dam is not expected to change due to change in temperatures relative to the No Action Alternative. The breach of the lower Snake dams would facilitate upstream expansion of shad in terms of passage.

## RESIDENT FISH

### Region A

#### *Kootenai River Basin*

Summary of Key Effects

MO3 would have the same key effects as the No Action Alternative. Current discharges from Libby Dam have detrimental effects to fish species in the Kootenai River downstream of Libby Dam. Spring water temperatures would continue to be too cold for the development of many aquatic species. Spring flows would also continue to increase at a rate less than normalized, thereby delaying and reducing productivity associated with inundated riparian and varial zone habitats. These reduced flow rates would also continue to limit productivity and may adversely impact food sources for resident fish downstream of Libby Dam.

Cottonwood seedlings would continue to have variable survival depending on timing, stage and duration of spring flows, along with winter stage during the ensuing winter. In addition, the discharge regime from Libby Dam would not provide for successful burbot recruitment, and spring water temperatures would be too cold to allow for proper larval development.

Habitat Effects Common to This Fish Community

MO3 would not change water temperatures in the spring from those under the No Action Alternative. However, similar to MO1 and MO2, MO3 would provide deeper end-of-December drafts than the No Action Alternative, with deep drafts of 11 feet in the wet years, and thus may enhance reservoir warming during the spring and early summer.

MO3 would have a lower rate of flow increase from Libby Dam in the spring compared to the No Action Alternative. This decrease in flow rate under MO3 would result in a greater delay in spring productivity than under the No Action Alternative.

MO3 would decrease the potential for cottonwood and willow seeding and recruitment compared to the No Action Alternative. Under MO3, there would be less area for seeding establishment than under the No Action Alternative. On average, there would be no habitat available under MO3 that is not flooded by winter scour flows compared to one foot of elevation above these flows in the No Action Alternative.

MO3 would have a similar rate of recession of river stage at Bonners Ferry during the seeding seasons than the No Action Alternative.

Bull Trout

Effects of MO3 to bull trout that differ from the No Action Alternative include lower flows below Libby Dam and increases in usable habitat for juvenile and adult bull trout.

Under MO3, Lake Koocanusa would be above elevation 2,450 feet for two more days during the summer productivity period than under the No Action Alternative. The expected result would be minor increases in productivity and an increased food web under MO3. In addition, fall water levels would be higher, on average, than under the No Action Alternative.

The minimum elevation of Lake Koocanusa under MO3 would be 7 feet lower, while the maximum elevation would be 1 foot higher than under the No Action Alternative. The expected result would be greater variability in water levels and more frequent annual dewatering and decreased benthic insect production, which may result in a decrease in bull trout growth and/or survival.

MO3 would have slightly lower discharges than the No Action Alternative, but would provide more usable habitat for juvenile (day and night) and adult bull trout than the No Action Alternative.

Kootenai River White Sturgeon

MO3 would provide an estimated one less day of peak discharge than provided by the No Action Alternative. This reduction in the ability to maximize the number of days flow exceeds 30 kcfs at Bonners Ferry relative to the No Action Alternative is negligible.

MO3 would provide a deeper end-of-December draft than the No Action Alternative, with drafts up to 11 feet deeper in wet years. These deeper drafts would likely lead to slightly lower productivity at Lake Koocanusa.

Other Fish

The median minimum elevation of Lake Koocanusa under MO3 would be 11 foot lower than under the No Action Alternative, while the maximum elevation would be 1 foot higher than the No Action Alternative. These conditions would have the same effects identified in the discussion above for bull trout.

Under MO3, there would be fewer days when Libby Dam would provide a discharge of 20 kcfs or greater when compared to the No Action Alternative. These flows would be insufficient to mobilize or reshape tributary deltas that can prevent bull trout access during the fall spawning season.

MO3 would have slightly lower discharges from Libby Dam from May 15 to September 30 than the No Action Alternative, but would provide slightly more usable habitat for juvenile and adult redband rainbow trout than the No Action Alternative, which may result in increased growth and/or survival of all life stages of redband rainbow trout.

Effects to burbot under alternative MO3 include lower and cooler winter flows during spawning. Median flows under Alternative MO3 as measured at Bonners Ferry between January 1 and April 30 would be lower than No Action Alternative. Median flows under Alternative MO3 would be more likely than the No Action Alternative to provide the low and stable flows to imitate pre-dam hydrographs during burbot spawning and incubation, and thus most conducive to successful burbot recruitment. In addition, these lower flows would cool more readily than higher flows and help induce successful spawning.

***Hungry Horse/Flathead/Clark Fork Fish Communities***

Summary of Key Effects

The measures that affect project operations at Hungry Horse Reservoir are the same as MO1. The only difference between MO1 and MO3 is that MO3 includes the *Ramping Rates for Safety* measure, which removes ramping rate restrictions that were put in place to minimize effects. The key operational effects of MO3 (same as MO1) are largely biological responses to changes in Hungry Horse Reservoir elevations and outflows to provide additional water supply. Lower elevations through the summer would decrease food supply for fish with slight reductions in plankton production and surface area for summer terrestrial insects. Benthic insect production important to fish would be decreased under MO3. Lower surface elevations could also increase rates of predation and harvest as fish are more vulnerable in shallower water as they migrate into and out of tributaries to fulfill their life cycles. Increased outflows in summer would likely result in increased entrainment of zooplankton and fish out of Hungry Horse reservoir. Increased flows in the South Fork Flathead River would be attenuated with flows from the mainstem Flathead River but would still result in higher summer flows that would decrease native fish habitat suitability in that reach. MO3 would have negligible effects on Flathead Lake, lower Flathead River, or Clark Fork River fish.

Habitat Effects Common to This Fish Community

Habitat effects due to Hungry Horse Reservoir elevations would be the same as MO1. See that alternative for detailed descriptions.

Because the elevation follows the same summary hydrograph as in MO1, the following parameters would also be similar:

- End of month volume of reservoir available to produce zooplankton would be 1 to 3 percent lower in summer.
- Magnitude and rate of drawdowns in reservoir elevation affecting benthic aquatic insect production. Benthic habitat reduced by at least 3 to 4 percent, with higher magnitude of effect in headwater bays.
- End of month surface area influencing available surface area for terrestrial insect feeding in summer and the distance from the water surface from the terrestrial vegetation, which influences what proportion of non-flying terrestrial insects drop to the water surface to be available for fish.

See Section 3.5.3.4, Multiple Objective 1, Resident Fish, Region A for detailed analyses of these relationships.

Outflow patterns from Hungry Horse Reservoir would also be very similar to MO1, with higher summer flows for additional water supply and lower spring, fall, and winter flows. Therefore, flows on down the system in the South Fork Flathead River, mainstem Flathead River, Flathead Lake, lower Flathead River, and Clark Fork River would also all be the same as MO1. See Section 3.5.3.4, Multiple Objective 1, Resident Fish, Region A for detailed analyses.

The key difference between MO1 and MO3 is that MO3 includes the measure to remove ramping rate restrictions that have been implemented over time to reduce fish effects from ramping rates. Increased ramping rates would increase effects on aquatic insect production and potential stranding of fish. This measure is also in MO2 and habitat effects are described in Section 3.5.3.5, Multiple Objective 2, Resident Fish, Region A. One other difference is MO3 outflows are lower for about two weeks in February.

<u>Bull Trout</u>

As described in the physical environment, MO3 conditions would slightly (1 to 2 percent) reduce the summer production of zooplankton that fuels the food web and surface area available for summer terrestrial insect feeding and substantially lower the benthic insect production, compared to the No Action Alternative. Reservoir elevations would be 3 to 4 feet lower in the late summer and fall in most years when bull trout migrate into tributaries and spawn, resulting in increased varial zone effects and potential tributary habitat blockage. This effect would be up to 12 feet in extremely dry years. Bull trout entrainment would be 9 to 21 percent higher due to increased outflows in late summer. Zooplankton entrainment would also be 9 to 21 percent higher than the No Action Alternative so there would be more plankton available in the South Fork Flathead River, but increased flows would decrease habitat available for transitory bull trout use. Summer median flows in the mainstem Flathead River would be 2 to 11 percent higher in summer than the No Action Alternative, further exacerbating issues with habitat suitability. Operations of Seli'š Ksanka Qlispe' Dam (Flathead Lake) would be similar to the No Action Alternative, and the bull trout habitat use and life history functions in Flathead Lake, the Lower Flathead River, and Clark Fork River would be similar to the No Action Alternative. See Section 3.5.3.4, Multiple Objective 1, Resident Fish, Region A for more detailed analyses.

<u>Other Fish</u>

Many effects described for bull trout would also apply to all of the native fish species in Hungry Horse Reservoir. Slight decreases in zooplankton, decreased macroinvertebrates, and reduced summertime feeding of terrestrial insects could reduce food supply slightly (1 to 2 percent) in summer. Compared to the No Action Alternative, Westslope cutthroat trout and other spring-spawning native fish would experience greater varial zone effects on their way upstream as adults, and could encounter some tributary blockages, but the delta formation of these tributaries is not known. Under MO3 operations, the modeled April and May elevations would be 5 feet and 3 feet, respectively, lower than the No Action Alternative. Juveniles typically outmigrate in June when the effects would be similar to the No Action Alternative. Entrainment from the reservoir would also continue at unquantified levels and could increase nine to 21 percent in the summer months with increased outflows. Habitat suitability described for bull trout would be similar for other native fish (Muhlfield et al. 2011), with higher summer flows in MO3 resulting in decreased amount of suitable habitat for them in summer. Effects to fish in Flathead Lake, the lower Flathead River, and Clark Fork Rivers would be similar as described in the No Action Alternative. See Section 3.5.3.4, Multiple Objective 1, Resident Fish, Region A for detailed analyses.

***Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River***

Summary of Key Effects

The key effects of MO3 for all resources in the Pend Oreille basin would be the same as those found under the No Action Alternative.

Habitat Effects Common to All Fish

Common habitat effects of MO3 would be the same as those identified for the No Action Alternative.

Bull Trout

Key effects to bull trout under MO3 are not different from the No Action Alternative.

Other Fish

Effects of MO3 would be the same as those identified under the No Action Alternative.

**Region B**

***Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam***

Summary of Key Effects

Flow, elevations, and water quality affect the quality of habitat for various resident fish species above, in, and downstream of Lake Roosevelt. The Columbia River from the U.S.-Canada border would continue to support a white sturgeon population that spawns successfully but primarily relies on fish manager intervention to survive a recruitment bottleneck; conditions for natural recruitment may be further diminished in a small proportion of years. In Lake Roosevelt, retention time is a key metric for most fish species in Lake Roosevelt, driving the food web that supports the fish as well as influencing how many are entrained and would be lower in November and December than the No Action Alternative. Lake elevations under MO3 would be similar to the No Action Alternative related to risk of impeded tributary habitat access and egg desiccation/stranding for redband rainbow trout. The portion of kokanee that spawn in tributaries would continue to have access in fall similar to the No Action Alternative. The effect of egg desiccation under MO3 would remain the same for burbot and kokanee. MO3 would continue to support both wild and hatchery-raised kokanee, redband rainbow trout and hatchery rainbow trout as well as non-native warmwater game species such as walleye, smallmouth bass, and northern pike. Northern pike would likely continue to increase and invade downstream and pike suppression efforts would be at similar levels as the No Action Alternative. Rufus Woods Lake would continue to provide habitat for fish entrained from Lake Roosevelt and from limited production of shoreline spawning by some species; entrainment could increase in winter and decrease in summer months. TDG would be similar or less than the No Action Alternative.

Habitat Effects Common to This Fish Community

The No Action Alternative would begin a shallow drop in early January where MO3 would hold steady through January and then drop into the winter draft in February. Initiation of refill would depend on the basin's water conditions but typically would begin in early May similar to the No Action Alternative in most years except the draft may be about a foot deeper in dry years. Elevation would then rise until mid-May where they would be the same as the No Action Alternative for the rest of the water year, reaching a target full pool of about 1,289 feet by July 4.

Median peak outflows follow the same pattern as the No Action Alternative with slightly reduced peaks in early June and July. The MO3 median flows in early spring through September would be about 2 percent to 5 percent lower than the No Action Alternative. November and December median flows would be about 2 percent to 4 percent higher than the No Action Alternative, while January flows would be 5 percent lower. These peak outflows can influence the rate of entrainment from Lake Roosevelt into Rufus Woods Lake. TDG in the Grand Coulee tailwater is also a concern for fish in Rufus Woods Lake. Under the MO3 TDG would be lower than the No Action Alternative.

Retention time of water through the reservoir is a driving metric for the food web in Lake Roosevelt and influences the populations of several fish species.

Generally speaking, under MO3 median retention time would be similar to or slightly higher than the No Action Alternative in late spring, summer, and fall. In all year types, retention time under MO3 would be 2 percent to 5 percent lower in November and December. In wet years, it would be slightly lower than the No Action Alternative (one percent to three percent) in spring. In wet years is when retention time is lowest because more water is moving through the system, and MO3 would reduce spring retention times even further in these years.

Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely directly on the food source provided by the zooplankton production and higher-level predators such as bull trout prey on these fish. Zooplankton are more widespread, more plentiful, and larger body size when retention times are higher, and tend to be smaller bodied, swept out of the reservoir faster, and more concentrated near Grand Coulee dam with lower retention time. With lower retention times under MO3 in winter and spring, when retention times are already fairly low, there would be less food available to fish, and they would also tend to follow the food source and crowd down towards the dam, becoming more susceptible to entrainment.

<u>Bull Trout</u>

Bull trout are temperature sensitive and would continue to use this reach for FMO habitat until temperatures reach stressful levels, which would be the same as the No Action Alternative. Bull trout in Lake Roosevelt could continue to move to cooler locations in the reservoir and these refuges would remain similar to the No Action Alternative. High flow years would continue to influence bull trout distribution through flushing more of them from the river near the U.S.-Canada border down into Lake Roosevelt. Similar to MO1, peak flows at the U.S.-Canada border were modeled showing a decrease of about 1 percent to 2 percent under MO3, which would likely be a negligible change to bull trout distribution. Increased outflows in November and December could potentially increase entrainment of bull trout, but this is negligible because of the scarcity of bull trout in Lake Roosevelt.

Bull trout prey base would continue to fluctuate as the fish they eat are sensitive to changes in productivity and location of zooplankton in Lake Roosevelt. Productivity and location are influenced by the retention time of water in the reservoir, which would be adversely affected by lower retention times in winter under MO3. Bull trout are also sensitive to contaminants that are found in this region and would continue to bioaccumulate contaminants as a top predator. Reservoir operations that would increase the exposure of shorelines and contaminant uptake and fluctuation events would be the same as the No Action Alternative.

<u>Other Fish</u>

In the Columbia River reach from the U.S.-Canada border to Lake Roosevelt, white sturgeon are typically able to spawn as evidenced by capture of young of the year larvae (Howell and McLellan 2018), but rarely experience successful recruitment from larvae to juvenile sturgeon, and only in extremely high water years. Successful recruitment, as documented in 1996, 1997, and 2011, appears to be dependent on a combination of flows exceeding 200 kcfs and water temperatures of about 14°C for 3 to 4 weeks in late June/early July (Howell and McLellan 2011 and Howell and McLellan 2014). Under MO3, these flows would slightly lower than the No Action Alternative. These slightly reduced flows at the U.S.-Canada border would result in potentially decreased recruitment window. The timing of these flows coinciding with lower reservoir levels can also increase recruitment ability with the longer riverine habitat provided by a lower reservoir. MO3 reservoir levels would be the same as the No Action Alternative. Recruitment window for sturgeon reproduction would be slightly reduced overall. Other factors that would continue to influence sturgeon include predation by fish that are favored by reservoir conditions if larvae are flushed into the Lake Roosevelt. Slightly lower flows in spring could slightly reduce the risk of larvae entering Lake Roosevelt. The uptake of contaminants such as copper closer to the U.S.-Canada border being flushed downstream into the reservoir by high flows would also be slightly lower. Under MO3, recruitment of white sturgeon would continue to be a rare event with slightly reduced recruitment. It would continue to be supplemented by hatchery propagation, as larval sturgeon are captured and raised in hatcheries until they are past the window where recruitment has been shown to fail at a high rate. Once these juveniles are released back into the reservoir they continue to grow and survive well. The reservoir would continue to provide good conditions for growth and survival of these fish.

Wild production of native fish such as burbot, kokanee and redband rainbow trout would continue to provide valuable resources in Lake Roosevelt. As described in the common habitat effects, these fish are the most sensitive to the effects of changing retention times. Under the No Action Alternative an estimated average of over 400,000 fish annually would be entrained, with 30 to 50 percent of them being kokanee, primarily of wild origin and rainbow trout the second most entrained species. Under MO3 operations, increased entrainment would be expected in November and December as the outflows increase over the No Action Alternative and retention times would be 2 percent to 5 percent lower. Previous entrainment studies (LeCaire 2000) indicated winter being a period relatively low entrainment; however, the prolonged drawdown period is expected to increase entrainment during this time. In wet years, entrainment would also be slightly higher in March to May (one percent to two percent lower retention time) which could increase entrainment slightly. Increased entrainment of zooplankton would decrease food availability that is key to winter survival and growth of several fish species including kokanee, juvenile burbot, and other juvenile fish.

For tributary spawning species such as redband rainbow trout and a portion of the wild production of kokanee, tributary access at the right time of year is important. Reservoir drawdown in the spring creates barren tributary reaches through the varial zone, which directly and indirectly impedes migration to and from tributaries and the reservoir. A lake elevation under MO3 would be sufficient to protect the access for the portion of kokanee that spawn in tributaries. Redband rainbow trout need access tributaries in the spring. Under MO3, reservoir elevations would be nearly the same as the No Action Alternative levels in the critical spawning migration time of April-May in wet years when varial zone effects are the highest due to deepest drawdowns.

Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible to egg desiccation if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on shoreline gravels September 15-October 15 and eggs incubate through February. Burbot tend to spawn successfully in depths provided by the MO3 in the Columbia River and in Lake Roosevelt on shorelines near the Colville River in winter with eggs incubating through the end of March (Bonar et al. 2000). MO3, compared to the No Action Alternative, would reduce the desiccation of eggs slightly because the reservoir holds slightly longer January in average years. Dry years could see minor changes with January levels in this 20 percent of years expected to drop slightly lower than the No Action Alternative, as well as a short-term reduction in levels during late November.

Burbot spawn later in the winter and would have similar effects as the No Action Alternative, except for the slight improvement noted in average years in January. Burbot spawn in the Columbia River above Lake Roosevelt and in reservoir towards the upper end; the river spawning fish would not be as susceptible to reservoir fluctuations and would be similar to the No Action Alternative.

Kokanee are very sensitive to water temperature, and during summer are found at depths below 120m to find suitably cool water. Under the No Action Alternative, Lake Roosevelt is very weakly stratified but does have suitably cool water at this depth along with suitable levels of dissolved oxygen. Lake whitefish and mountain whitefish also likely use this cool water in the summer.

Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish, crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all tolerate a wide range of environmental conditions and would continue to contribute to the fishery community under the MO3, and continue to adversely impact native species via predation. The invasion downstream by northern pike is of concern, and the Lake Roosevelt Co-Managers are actively suppressing pike populations using gillnets set by boats as soon as they can get on the water in the spring until the boat ramp becomes unusable at elevation of 1,235 feet. Under the No Action Alternative this occurs on April 15 in wet years, boat ramps remain useable in dry and average years. This would be the same in MO3. It should be noted that is only one boat ramp, but the middle of Lake Roosevelt area becomes inaccessible earlier, at lake elevation 1,245’. Additionally, outflows and retention time would continue to influence the entrainment and downstream invasion of non-native gamefish below Chief Joseph Dam where ESA-listed anadromous salmonids would be susceptible to predation by them. During the time when pike juveniles would be most susceptible to entrainment (May to August), retention time under MO3 would be similar or slightly higher so entrainment risk for pike would be similar to the No Action Alternative or slightly lower.

Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt would experience similar effects as their native counterparts except for spawning and early rearing effects. In addition, the net pen locations are situated where the water quality can be affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG, and their eventual recruitment to the fishery can be affected by retention time coupled with reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May. Under the MO3, the water quality at these locations would be similar to the No Action Alternative, and the retention time in May would be either similar or slightly higher so entrainment risk would be the same as the No Action Alternative or slightly less. The net pen operators strive to release these fish to coincide with the initiation of reservoir refill when outflows are reduced, which under MO3 would be the same as the No Action Alternative, so these fish would continue to be release when water quality conditions would be suitable.

The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter drawdown periods. The increased flows and shorter retention times in November and December may increase entrainment and boost populations in Rufus Woods Lake, where decreased outflows in August and September likely would decrease entrainment. This lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short retention time and low productivity. High flows during late spring and early summer would continue to flush eggs and larvae from protected rearing areas similar to the No Action Alternative, but slightly lower magnitude. Median peak outflows occur in early June and would be about 3 percent lower than the No Action Alternative. TDG in the Grand Coulee tailwater is a concern for fish in Rufus Woods Lake; modeling showed TDG would be lower than the No Action Alternative.

***Chief Joseph to McNary Dam***

Summary of Key Effects

Key effects under MO3 that differ from those of the No Action Alternative would be the long-term restoration of fragmented populations of white sturgeon. There would be slight reductions in flows and minor reductions in productivity in the McNary reservoir for two to seven years following the breaching of the four lower Snake River dams. Connectivity of the Columbia River with the Snake River would increase. Increased white sturgeon spawning and recruitment, minor increases in turbidity below the Snake and Columbia River confluence, and slight reductions in smallmouth foraging success are also expected.

Habitat Effects Common to All Fish

Under MO3, the breaching of the four lower Snake River dams would lead to an increase in spring sediment levels in the McNary pool below the confluence of the Snake and Columbia Rivers. There would be a substantial increase in connectivity of the Columbia River with mainstem riverine habitats on the lower Snake River.

Bull Trout

Key effects to bull trout under MO3 would not differ from those of the No Action Alternative.

Other Fish

Effects to white sturgeon from MO3 are similar to those of the No Action Alternative. However, under this alternative there would be slight reductions in high flows of May and June, potentially leading to minor reductions in white sturgeon spawning success. In addition, white sturgeon require large sections of riverine habitat for successful spawning and recruitment. Under MO3, there would be a major increase in connectivity of riverine habitats for white sturgeon. Populations in the McNary pool and Hanford reach would have access to hundreds of miles of the lower Snake River, up to Clearwater River and the Hells Canyon complex.

Key effects to fish species in this reach under MO3 would include a slight reduction in productivity of the McNary pool downstream from the Snake River confluence for two to seven years. Deposition of sediments in McNary pool following the breaching of the four lower Snake River dams would increase. There is a potential reduction in foraging success of smallmouth bass due to increased turbidity during breaching and during runoff and heavy rain events. Following the breaching of the four lower Snake River dams there would be a reduction in downstream drift of small fish and aquatic invertebrates that would reduce forage for resident fish from two to seven years. While breaching, and during high runoff or rain events shortly following breaching, large quantities of sediment would be deposited in the McNary pool just below the confluence of the Snake and Colombia River. This sediment would alter these habitats by silting in gravel coble habitats and reducing the benthic organisms that depend on them. Increased turbidity is associated with reduced foraging success of smallmouth bass and other visual feeders. Under MO3, there would be an increase in seasonal turbidity in the McNary pool from sources upstream in the Snake River. Smallmouth bass foraging success would be reduced by some unknown amount during runoff and heavy rainfall events.

**Region C**

***Snake River Basin***

Summary of Key Effects

Key effects to resident species under MO3 can be broken into short and long-term effects. Short term effects include high sediment and low oxygen concentrations that would likely lead to the loss of most of the fish in this reach during breaching, reduced forage and productivity for 2 to 7 years following breaching, and potential migration barriers at tributaries that may become perched during reservoir drawdown. Long-term effects would likely include changes in water temperature regimes with warmer water temperatures in the spring and cooler water temperatures in the fall, changes in resident fish communities from reservoir to riverine species, improved fish passage and habitat connectivity, major reductions in TDG, and improved spawning habitat of river spawning species.

Habitat Effects Common to All Fish

Under MO3, habitats would change considerably. Water velocities in the lower Snake River would increase nearly tenfold shifting the fish community to one dominated by riverine species. Substrates would revert to more cobble gravel and less silt and sand, and water levels (river stage) would have greater seasonal variation.

Bull Trout

The breaching of the four lower Snake River dams under MO3 would result in short- and long-term changes to bull trout use in the lower Snake River as compared to the No Action Alternative. Low numbers of bull trout would continue to use the lower Snake River as a migration corridor and for foraging and overwintering from November through June. However, breaching of the dams would allow for easier passage and better connectivity between populations. High suspended sediment levels and very low DO levels during dam breaching and the years following would adversely affect bull trout. Any bull trout in the river at that time may experience elevated levels of mortality. Overall water temperatures following dam breaching would be cooler for much of the year. However, May and June water temperatures would be higher.

Because breaching would occur about a month before bull trout would be entering the mainstem Snake River in the fall, potential passage effects from construction may be reduced. In the short term, passage into the tributaries may be adversely affected as sediment deposits may prevent bull trout from re-ascending tributaries in the spring.

Bull trout would no longer be entrained at the dams and would not need to use fish ladders to move upstream. High flows in the river may cause seasonal velocity barriers for bull trout at the dam sites when water reaches velocities over 12 feet per second as it passes through the breached portion of the dams. However, the remaining dam structures may provide foraging areas for bull trout as they overwinter and during migrations.

Because the volume of water would be reduced, water temperatures would change faster in response to environmental inputs (i.e., warmer air temperatures or cold snowmelt). Water temperatures are expected to warm sooner in the spring, and cool earlier in the fall. Daily water temperature fluctuations would be larger as well. Overall, yearly water temperatures would be cooler and more suitable for bull trout, resulting in reduced stress and improved survival. However, water temperatures would be higher in June and July and may induce bull trout to migrate from to cooler tributary habitats earlier in the year. Under MO3, TDG levels would be reduced to 104 to 105 percent year-round. This reduction in TDG would benefit bull trout.

Immediately following breaching of the lower Snake River dams, suspended sediment loads in the Snake River would be greatly increased and DO decreased relative to the No Action Alternative. DO levels in the river at that time would be low enough that any bull trout in the mainstem could experience increased levels of mortality. As suspended sediment levels decrease, DO levels would return to normal levels that would support bull trout. Long-term effects of MO3 would include elevated sediment during the spring freshet the year following dam breaching. These conditions may adversely affect bull trout.

Unlike the No Action Alternative, under MO3 there would likely be a temporary reduction in forage for bull trout. As river flows clean the sediment from embedded cobble and gravel, invertebrate populations would expand and productivity would increase. This reduced productivity is estimated to be about 2 to 7 years. Forage fish and invertebrates would be expected to increase over time. The change of the food base from zooplankton to macroinvertebrates in the river would benefit sub-adult bull trout.

<u>White Sturgeon</u>

The breaching of the four lower Snake River dams under MO3 would increase connectivity between McNary Reservoir, Hells Canyon, and spawning habitat in the lower Snake River. Short-term effects would include high levels of suspended sediment and very low DO levels during dam breaching. Any white sturgeon in the river at that time may experience increased levels of mortality.

Spawning of white sturgeon in the Snake River basin under MO3 would change relative to the No Action Alternative. The breaching of the four lower Snake River dams would increase the amount of spawning habitat available in this reach and produce higher water velocities that would induce spawning. Suitable spawning substrates would expand from an estimated 226 to 3,521 acres under a breach scenario. Modeling shows that average velocities in a breached scenario would reach between 6 and 8 ft/sec during the spring runoff compared to less than 1 ft/sec under the No Action Alternative. These conditions would lead to more successful spawning and recruitment for white sturgeon.

Water temperatures in the lower Snake River under MO3 would change from those of the No Action Alternative. Water quality modeling shows that water temperatures would likely be 2 to 4 degrees Fahrenheit warmer in June and July and 2 to 4 degrees Fahrenheit cooler in September through December under this alternative. Earlier warming may induce adults to spawn earlier and reduce any adverse effects. Water temperatures in the lower Snake River would continue to be suitable for egg incubation under MO3. However, more days would likely exceed optimum temperatures for egg incubation than under the No Action Alternative.

The ability of the Snake River to provide rearing habitat for the yolk sac larvae and juvenile white sturgeon under MO3 would be different in both the short and the long term from that under the No Action Alternative. In the short term, release of sediments during dam breaching would temporarily cover cobble and gravel substrates with silt and sediment, reducing hiding cover for sturgeon sac fry and invertebrates that provide forage for juvenile sturgeon. The substrate would be scoured clean in two to seven years and would likely improve habitat for both spawning and rearing long term. River mechanics modeling (see Section 3.3) shows that following dam breaching, currently existing sediment deposits would likely be scoured to the original riverbed.

Migration of white sturgeon through the lower Snake River would improve in the long term under MO3. Breaching of the four dams would reconnect white sturgeon populations from McNary Reservoir to Hells Canyon. Movement between populations would be unrestricted and spawning habitat would increase. Recruitment would also likely increase. In the short term, there would be no upstream passage, as water quality conditions during dam breaching may not support sturgeon passage.

TDG levels would be greatly reduced under MO3 relative to the No Action Alternative. Under this alternative, TDG conditions would be ideal for most of the lower Snake River as there would be no spill at the four dams to raise TDG levels. Modeling shows under MO3 TDG levels would not exceed 110 percent at any time during the year, and that the highest TDG level would be approximately 104 percent. No adverse effects from TDG on white sturgeon are expected under MO3.

The effects of suspended sediment loads in the Snake River reservoirs on white sturgeon under MO3 would be very different from those under the No Action Alternative. During, and immediately following, breaching of the lower Snake River dams, suspended sediment loads in the Snake River would increase up to 25,000 mg/l for a short period of time and loads of about 5,000 mg/l for may extend for 18 to 26 days following each of the dam breaching events. These sediment concentrations would result in a 20 to 40 percent mortality of white sturgeon.

Further, chemical and biological oxygen demands associated with dam breaching and the increased suspended sediment could lower DO levels in the river to 2 ppm. Short-term effects to white sturgeon could result in periods of significant mortality. The loss of mature adult fish would be a major adverse effect. As suspended sediment levels decrease, DO levels would return to normal levels that would support white sturgeon.

The breaching of the Snake River dams under MO3 would have a much greater potential to affect contaminant levels in the river than the No Action. Dam breaching would re-entrain dormant sediments that may contain elevated concentrations of heavy metals, pesticides, and other chemicals of concern. These chemicals of concern would have an unknown impact on white sturgeon

<u>Other Fish</u>

Effects to resident fish from MO3 that differ from those of the No Action would include the loss of fish and invertebrates during and shortly following dam breaching, an increase in mean water velocity, the conversion of reservoir habitats to riverine habitats, a reduction in TDG levels, an increase in spawning habitat for riverine species, and changes in water temperature regimes.

Effects from MO3 can be broken into short- and long-term effects. Short-term effects to resident fish species from dam breaching would include elevated sediment concentrations and reduced oxygen levels. Sediment levels may reach 25,000 mg/l for short periods of time and over 5,000 mg/L for 18 to 20 days. Similar to bull trout, these levels of suspended sediment may induce mortality rates between 20 and 60 percent for resident fish depending on the species. Chemical and biological oxygen demands associated with dam breaching and the increased suspended sediment could lower DO levels in the Snake River to approximately 2 ppm. These reduced oxygen concentrations could result in significant levels of mortality in the lower Snake River. Short-term effects could also include the loss of macroinvertebrate or significant reductions to populations that provide forage for most of the resident fish community. This reduced forage base is expected to last between two and seven years as flows from a new river scour embedded substrates that would house invertebrate populations.

Long-term effects from MO3 would include large decreases in TDG concentrations and altered water temperature regimes throughout the lower Snake River. Under MO3 TDG is not expected to reach 105 percent and risk of GBT to resident fish would be reduced. Water temperatures under this alternative would be 2 to 4 degrees Celsius warmer in spring and 2 to 4 degrees Celsius cooler in the fall. These changes in temperature may alter spawn timing and success for resident fish species.

Under MO3 there would be major changes in aquatic habitats available to resident fish species. Large reductions in slow water habitats would occur with major shifts to riverine habitats. One important metric to measure these changes is water velocity. Mean annual water velocity would increase from less than 0.5 ft/sec under the No Action Alternative to about 4 ft/sec under MO3. This increase in velocity would alter the fish community such that reservoir-dependent species would be reduced and riverine species would increase. Relative abundance of walleye, crappie, and northern pikeminnow would decline under MO3, while concentrations of smallmouth bass would remain the same or increase slightly and the abundance of white sturgeon would increase. Changes in habitat would include increased spawning habitats for riverine species while slow water rearing habitats would be reduced to backwater and side channel areas.

The change from reservoir to riverine habitats under MO3 would also alter the productivity and forage base for resident fish species. Forage resources would convert from a zooplankton-dominated reservoir to an insect-dominated river. Zooplankton are expected to drop to less than 10 percent of the current biomass and would be replaced, in time, with macroinvertebrates. Productivity is expected to be reduced during the dam breach but would slowly return over time.

**Region D**

***Mainstem Columbia River from McNary Dam to the Estuary***

<u>Summary of Key Effects</u>

Bull trout would continue to use the Columbia River in limited numbers and seek cold water refuge available at the mouths of tributaries. White sturgeon would continue to successfully reproduce in years with adequate flow and temperature conditions.

<u>Habitat Effects Common to this Fish Community</u>

Outflows from McNary Reservoir influence some of the fish relationships described in this section. Peak spring flows affect habitat maintenance for some species. Modeled median outflows for MO3 indicate that outflows would be within 3 percent of the No Action Alternative (no discernable change).

Other flow parameters referred to in this section refer to outflows of McNary Dam, which are indicative of flows on downstream through the other Projects.

<u>Bull Trout</u>

Bull trout are known to use the mainstem Columbia River to move between tributaries and have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et al. 2016). Water temperature is the most important habitat factor for bull trout in the mainstem Columbia. Under MO3, bull trout would continue to use the mainstem Columbia for migration between tributaries, as well as tributary mouths for passage and thermal refugia.

Adult bull trout move downstream during fall and overwinter in reservoirs (October to February; Barrows et al. 2016). Although bull trout successfully move between areas on the mainstem, their migration can be delayed at the dams. MO3 includes structural measures for additional spillway passage at McNary Dam. This measure would be in operation from March 1 through August 31, and could slightly improve bull trout downstream passage, but the majority of adult bull trout would have moved out of the mainstem by the time this surface passage route would be in use.

Passage through turbines can cause injury or mortality MO3 includes turbine replacement with IFP turbines, which would improve survival (Deng et al. 2019). At John Day, turbine replacement would provide safer passage for any bull trout that move through the dam.

Bull trout would continue to be subject to bird predation.

<u>Other Fish</u>

Under MO3, white sturgeon spawning and recruitment would be similar to the No Action Alternative. In low flow years, it is likely that there is very little spawning and recruitment, but overall conditions would be similar to the No Action Alternative.

Model results indicate suitable spawning temperatures would be similar to the No Action Alternative. In years of low flow conditions, water temperatures could increase beyond the suitable range by early June, resulting in little or no recruitment.

White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse substrates (Parsley et al. 1993). Dam breaching upstream under MO3 could result in some amount of sediment increase downstream.

Lack of effective upstream white sturgeon passage for all age classes decreases the connectivity of the population (Parsley et al. 2007). Under MO3, a measure to improve fish passage at Bonneville Dam would likely improve potential passage for sturgeon. The vertical slot fishway could make it easier for sturgeon to pass upstream.

Turbine units at dams can cause injury and mortality in juvenile and adult sturgeon. Under MO3, improvements to turbines at John Day would reduce injuries and mortality of sturgeon (Deng et al. 2019).

White sturgeon larvae are adversely affected by TDG. Studies have shown high rates of altered buoyancy at 118 percent TDG, and 50 percent mortality at 131 percent TDG (Counihan et al. 1998). Adults are more able to compensate for increased TDG by moving to lower depths, but larvae in shallow water would be more adversely affected. Under MO3, TDG rates would be less than the No Action Alternative at McNary and Bonneville Dams in August but would be higher at The Dalles and Bonneville from mid-April through mid-June. Since the earlier spring months are when larvae would be more likely to be present, overall this would be a represent a minor increase in adverse effects compared to the No Action Alternative.

Under MO3, pool elevations could be about 1 foot higher in the John Day pool, which provides more habitat for juveniles, but subsequent drops in elevation could lead to juvenile stranding. MO3 may result in increased sediment transport through the lower Columbia River and increase sedimentation in these reservoirs.

Under MO3, no changes to resident fish communities would be expected. As shown above, outflow rates below McNary Dam would be very similar to the No Action Alternative. Water quality and food availability would also be similar to the No Action Alternative.

Conditions that promote lower water temperatures and higher spring flows tend to lower the survival rates of warmwater game fish, potentially lowering populations of predators on salmon and steelhead. MO3 would be expected to continue supporting warmwater game fish at levels similar to current conditions.

**MACROINVERTEBRATES**

Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under MO3. For more detailed information on the effects of MO3 on aquatic invertebrates and implications on food web interactions see the Habitat Effects section of these respective fish community analyses in the Resident Fish section under the applicable region.

**Region A**

Project operations under MO3 would affect the aquatic environments provided by Hungry Horse Reservoir, South Fork Flathead River, Flathead River, Flathead Lake, lower Flathead River, Clark Fork River, Lake Pend Oreille, Pend Oreille River, Lake Koocanusa, and the Kootenai River. Hungry Horse Reservoir and Albeni Falls Reservoir operations would both be the same under MO3 as MO1 and effects to aquatic macro-invertebrates would be the same (see Section 3.5.2.3 for a discussion of the macroinvertebrate effects under MO1).

Hungry Horse reservoir would experience increased dewatering of insects through the summer because of reduced varial zone habitat. Lower summer elevations would also result in decreased summer zooplankton production, and increased release of zooplankton out of the reservoir and into the South Fork Flathead River with higher outflows. South Fork Flathead River flows could increase zooplankton levels and wetted area for macroinvertebrate production in the South Fork Flathead River but could also flush more out of this area with higher velocities. MO3 operations would result in negligible changes to Flathead Lake, the lower Flathead River, and the Clark Fork River. These habitats would continue to support the macroinvertebrates described in the affected environment.

The operations of Albeni Falls Project would be very similar to the No Action Alternative and MO1 operations and would not result in appreciable changes to Lake Pend Oreille or the Pend Oreille River, nor the macroinvertebrate communities in those habitats.

In the Kootenai basin, MO3 operations would diverge from the No Action Alternative with deeper, steeper drafts in winter. Summer elevations would be similar to MO1. Lake Koocanusa would be held above elevation 2450 from one to two more days than the No Action Alternative, which would result in similar overall productivity of zooplankton and macroinvertebrates in the system.

**Region B**

The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic insects such as stonefly, caddisfly, and mayfly larvae. The river elevation in this reach is influenced by Lake Roosevelt operations and inflows so is somewhat variable, which would constrain benthic production to some degree.

MO3 river stage at the U.S.-Canada border and downstream into Lake Roosevelt would be the same as the No Action Alternative. Macroinvertebrate habitat would not be affected. In Lake Roosevelt, the elevations would also be the same as under the No Action Alternative, with the minor exception that the winter elevation would be held level about two weeks longer than under the No Action Alternative, just prior to the winter draft. This would be a slight benefit to aquatic invertebrate production.

In Lake Roosevelt, the production, distribution and persistence of zooplankton is highly variable and sensitive to how long the water stays in the reservoir (retention time), which is a function if inflows, reservoir volume, and outflows. Longer water retention times allow for more and larger-bodied zooplankton to be more widely distributed throughout the reservoir. Lower retention times result in fewer and smaller-bodied zooplankton that get concentrated near the dam, where they would be subject to high rates of entrainment. Generally speaking, under MO3 median retention time would be similar to or slightly higher than the No Action Alternative in late spring, summer, and fall. In all year types, retention time under MO3 would be 2 percent to 5 percent lower in November and December. In wet years it would be slightly lower than the No Action Alternative (1 percent to 3 percent) in spring. In wet years retention time is generally lowest because more water is moving through the system, and MO3 would reduce spring retention times even further in these years.

Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short retention time and low productivity. Aquatic insect production and desiccation, river stage at RM 594 in Rufus Woods Lake would follow the same pattern and magnitude changes under MO3 as the No Action Alternative. The stage would be slightly lower (less than a half of a foot) through the spring, but the change to macroinvertebrate habitat would likely be negligible.

**Region C**

Dworshak Reservoir elevations would be the same as the No Action Alternative. Benthic production in the reservoir would continue to be low due to the extensive variation in water surface elevation, near-shore wave action that causes erosion, and the lack of aquatic plants along the shoreline. Likewise, outflows would be the same as the No Action Alternative. Benthic communities in the Clearwater River below Dworshak Reservoir would continue to be limited by unsuitably high flows in summer and late winter.

The breaching of the four lower Snake dams would result in a shift to macroinvertebrate communities. Organisms in the rivers downstream of breach sites would likely experience substantial mortality in the short-term immediately following breach due to elevated suspended sediment and major reductions in dissolve oxygen that would move downstream (see Section 3.4, *Water Quality*). Over time, as the river reached a state of equilibrium, conditions would be shifted from reservoir habitats to more natural riverine habitats. Species richness would likely increase over time. Opossum shrimp and Siberian prawns would likely be reduced in numbers as they favor slow-moving lake habitats. The rock and riprap substrate that provide crayfish habitat would be reduced as dam sites and other structures would be dewatered. As the river flows cleared out accumulated sediments over the course of several years, there would be a shift from more soft sediment habitat dominated by worms to more hard habitats with a higher diversity of aquatic macroinvertebrates. Mussels, clams, and snails that prefer lake habitats would be reduced.

**Region D**

MO3 would result in only minor changes to flows or temperatures that could affect macroinvertebrate communities in the lower Columbia River. Very little benthic macroinvertebrate information is available for the lower Columbia River. Lake habitats in the impounded reaches would continue to support a low diversity of worms, benthic insects, and mollusks. The breach of Snake River dams could result in increased sedimentation in some areas of the lower Columbia River, possibly resulting in a species shift of more worms, mollusks, etc. that prefer soft substrates in these localized areas. The run of river dams would continue to be operated at stable elevations that would continue production of these aquatic macroinvertebrates.

**SUMMARY OF EFFECTS**

**Anadromous Fish**

Model results indicate that the breaching of the four lower Snake River projects is expected to have major beneficial effects on juvenile outmigration and adult upstream migration. This MO would end juvenile transportation from the Snake River and would likely lead to a transition in hatchery mitigation tied to those dams as described in the mitigation measures in Chapter 5.

Under MO3 there is a slight increase predicted in upper Columbia spring Chinook salmon in-river survival and no change to steelhead relative to the No Action Alternative. These changes are primarily due to increased spill levels in the lower Columbia River. CSS model results were not available (no model results were able to be produced) for upper Columbia River species in this EIS. Results from the NOAA LCM indicate that the level of improvement to upper Columbia spring Chinook SARs is dependent on the level to which latent mortality affects this stock. If increased spill in the lower Columbia River does not improve ocean survival, (i.e. reduce latent mortality) the LCM model predicts negligible to minor improvements in SARs (one percent relative increase). Larger reductions in latent mortality would result in larger predicted increases in both SARs and abundance for Upper Columbia stocks (4 to 147 percent relative increase in abundance).

Quantitative model results from both the CSS and LCM were available indicated a range of potential long-term outcomes largely due to how the models address latent mortality. The CSS models predict that outmigrants from Lower Granite that return to Lower Granite (SARs) would increase by 170 percent relative to the No Action Alternative. The NOAA LCM predicted that SARs from Lower Granite to Bonneville would improve by 14 percent relative to the No Action Alternative. The CSS model predicted similar improvements for Snake River steelhead. NOAA did not produce LCM model estimates for Snake River steelhead.

MO3 is also expected to provide a long-term benefit to species that spawn or rear in the mainstem Snake River habitats, such as fall Chinook. By breaching the four lower Snake River dams, major short-term adverse impacts to fish, riparian and wetland habitat in the Snake River and confluence of the Columbia River would occur, associated with the initial breaching the dams, drawing down the reservoirs, and time for the river to move sediment and stabilize. These effects are expected to diminish over time. MO3 also includes structural modifications to infrastructure at the dams to benefit passage of adult salmon, steelhead, and Pacific lamprey.

Maximum summer water temperature would increase slightly; water temperature variability would increase; and water temperatures would not stay cool as long into the spring and would cool earlier in the fall with the removal of the thermal inertia of the lower Snake dam reservoirs. 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 species are expected to be major and beneficial once short term adverse effects associated with dam removal have subsided.

**Resident Fish**

Habitat effects outside of the Snake River would remain minor and similar to those in MO1. In Region A, higher lake elevations under MO3 would result in higher productivity at areas such as Lake Koocanusa, while effects at Hungry Horse would be similar to MO1 (minor to moderate adverse due to reduced food productivity in summer and lower lake elevations). In Region B, the effects to Lake Roosevelt are expected to be minor when compared to the No Action Alternative. Winter drawdown is expected to increase entrainment, but the varial zone/tributary access impacts are comparable to the No Action Alternative. In Region C, long-term effects would likely include changes in water temperature regimes with warmer water temperatures in the spring and cooler water temperatures in the fall, changes in resident fish communities from reservoir to riverine species, improved fish passage and habitat connectivity, major reductions in TDG, and improved spawning habitat of river spawning species. Short term effects include high sediment and low oxygen concentrations that would potentially lead to the elevated mortality for fish in this reach during breaching, reduced forage and productivity for 2 to 7 years following breaching, and potential migration barriers at tributaries that may become perched during reservoir drawdown. These adverse short-term effects and beneficial long-term effects in the Snake River are expected to be major. Effects in Region D would be minor adverse to negligible.

**Macroinvertebrates**

Habitat effects outside of the Snake River would remain minor and similar to those in MO1. All organisms in the rivers downstream of breach sites would likely experience substantial mortality in the short-term immediately following breach due to the pulses of sediment traveling downstream. At Libby Dam, high flows would decrease the potential for cottonwood and willow seeding and recruitment. Structural changes at McNary and John Day would improve passage for bull trout and other species. Over time, as the river reached a state of equilibrium, conditions would be shifted from the reservoir habitat to more natural riverine habitats. Species richness would likely increase over time, with a shift toward species preferring riverine habitats. These adverse short-term effects and beneficial long-term effects in the Snake River are expected to be major.

### *3.5.3.7 Multiple Objective Alternative 4*

**ANADROMOUS FISH**

**Salmon and Steelhead**

Several different ESU/DPS units of salmon and steelhead share a similar life cycle and experience similar effects from the MOs, but also have ESU/DPS specific traits that specifically drive effects differently from one another. Common effects analyses across all salmon and steelhead are discussed first, and then those ESU/DPS specific effects are displayed.

***Effects Common Across Salmon and Steelhead***

<u>Summary of Key Effects</u>

MO4 includes several structural and operational measures intended to improve juvenile salmon and steelhead migration and survival, including incremental improvements in powerhouse surface passage routes and improved survival of fish that go through the turbines. Increases in spill, drawing down lower river reservoirs, and additional flow augmentation in dry years are expected to decrease the travel time of in-river fish, and decrease powerhouse encounter rates, but TDG exposure would increase. Fewer smolts would be transported. Adult migration would be enhanced by structural measures to reduce delays in the Snake River projects, and steelhead kelt survival would be improved with the addition of spillway weir notch inserts, but adult delays and fallback may be increased with more spill. In the balance between survival benefits of transporting fish compared to increasing the speed and survival of in-river fish, MO4 leans towards less transport and increasing the number of fish migrating in-river. The overall benefits to abundance of returning salmon and steelhead would depend on the degree to which latent mortality affects ocean survival of in-river fish. Unless otherwise noted, quantitative results from COMPASS and the Life Cycle Model (LCM) are based on a combination of hatchery and natural origin fish. This applies for both juvenile and adult results.

Juvenile Fish Migration/Survival

There are two structural measures in MO4 that may affect juvenile migration and survival. These are also in MO1 and are described in more detail there, but are summarized here:

- **Construct additional powerhouse surface passage routes** at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and John Day Dams: This would route additional juvenile fish away from turbine passage routes to spillway or spillway-like routes, likely decreasing travel times and increasing survival. See MO1 Common Effects for details. As discussed in MO1, even with the most optimistic 30 percent passage efficiency assumption in place, the effect of these powerhouse surface passage structures on in-river survival and subsequent adult returns was minor. This is especially relevant in MO4, which employs spill up to the 125 percent TDG cap at all eight fish passage dams. These structures could potentially be more effective at influencing population level dynamics at lower spill levels than those included in MO4, but powerhouse passage is estimated to be so low under 125 percent spill levels there were not enough fish passing via the powerhouse to have a meaningful impact.
- **Install IFP turbines at John Day Dam** would improve juvenile survival of the juveniles that pass through this turbine route. See MO1 Common Effects for details.

Additionally, MO4 includes a measure that was designed to improve overwintering adult steelhead and kelt survival but may also improve juvenile migration.

- **Adding spillway weir notch gate inserts** at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and John Day Dams would allow the attraction of smolts and overwintering steelhead later into the season, and would allow the attraction using one fourth of the water. An increase in the total number of fish passing via surface routes is expected. See adult survival and migration section below for more details about this measure.

Several operational measures warrant discussion here individually, regarding effects to juvenile fish. Measures that would result in changes to spill, flows, passage routes, or temperatures were incorporated into the fish models. Others could not be incorporated into modeling for effects analysis, or are modeled but may be difficult to separate from other factors; effects of these measures are discussed qualitatively.

- MO4's spill to 125 percent TDG increases the proportion of spill at each of the lower Columbia and lower Snake projects compared to the No Action Alternative. The higher spill has the net effect of routing greater numbers of juvenile salmon and steelhead into spill routes and fewer through powerhouse routes such as the juvenile fish bypasses and turbine routes. For juvenile salmon and steelhead, quantitative fish modeling was used when available to estimate the effects of these spill changes on fish.
- Drawing down the lower Columbia River projects to at, or near, MOP elevations will reduce water travel time to some degree relative to the No Action Alternative. At the same time,

these drawdowns in the John Day pool would expose additional nesting habitat on Blalock Island and likely increase the risk of avian predation in this area for all species.

- Holding contingency reserves within juvenile fish passage spill is likely to have little effect on juvenile migration. These measures were both included in the 80-year modeling datasets.
- The McNary Dam flow target measure is intended to provide additional spring flow augmentation in dry years to improve juvenile outmigration. More water in the Columbia River in dry years could increase survival of outmigrating juveniles by reducing in-river travel times. The effects of this measure were estimated by the primary fish models.
- Several measures in MO4 affect juvenile fish transportation rates and effects of these changes differ by ESU/DPS. Overall, the higher spill in MO4 decreases the proportion of juvenile salmon and steelhead available for transport. In addition, juvenile transport would be suspended from June 15 to August 15, when it would be re-initiated and extended until November 15 at the three lower Snake collector dams.
- Operating turbines above 1 percent peak efficiency could affect juvenile Snake River spring-run/summer-run Chinook direct survival. This measure is also in MO2 and MO3; see those alternatives for more details.

The full suite of operational measures would change flow patterns in the Lower Columbia River with decreases in monthly average flows of 1 to 3 percent from April to June and a decrease of 2 to 4 percent in month average flow in August. In the driest years, monthly average flows in May would be 12 percent higher than the No Action Alternative. Similar to the spill changes, fish modeling was used when available to estimate the effects of these flow changes on juvenile fish.

Overall, MO4 is distinct compared to the No Action Alternative from a TDG perspective. There is substantially higher spill during the March-August period that generates higher and more prolonged elevated TDG relative to the No Action Alternative. UW/CBR TDG modeling, separate from COMPASS and CSS in-river survival estimates, estimated higher reach average exposure to TDG indices.

There may be decreases in fish injury under MO4 with the lower number of powerhouse passages relative to the No Action Alternative and further reduced to some degree by installation of improved fish passage turbines at John Day Dam. Turbidity is not anticipated to change under MO4 relative to the No Action Alternative, as forebay drawdowns to near minimum operating pool elevations in the lower Columbia may temporarily have minor total suspended solids/turbidity effects, but they are expected to be minor given the size of large reservoirs. There may be an overall decrease in juvenile fish predation exposure under MO4 due to these factors relative to the No Action Alternative, but the magnitude is uncertain. In some reservoirs, predation rates could potentially increase if poor tailraces conditions (e.g. eddies or other confusing flow patterns) are created by high spill levels. Changes in operations of Grand Coulee Dam under MO4 could increase entrainment of northern pike, hastening the invasion of this predator downstream where salmon and steelhead are found, thus increasing their predation exposure.

Adult Fish Migration/Survival

There are several operational and structural measures in MO4 that may affect adult salmon and steelhead. Two of these structures are in MO1 so are described in detail there and summarized here:

- **Improve adult ladder passage** through modification of adult fish trap at Lower Granite Dam would reduce delays in migration through Lower Granite Dam.
- **Installing pumping systems** to provide deeper, cooler water if available in adult fish ladders at Lower Monumental and Ice Harbor dams would decrease the temperature differential in fish ladders that can delay adult migration when surface waters are warm.

Additionally, MO4 includes a unique measure not in any other alternative, which was designed to improve overwintering steelhead and kelt survival:

- **Add spillway weir notch gate inserts at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, and John Day Dams.** During the late fall and early winter adult steelhead that have overshot their natal streams, may overwinter in mainstem habitats. In the spring, some steelhead that have spawned (kelts) are attempting to return to the ocean and often pass downstream of project dams on the Snake and Columbia rivers prior to juvenile spill operations. Historically, spill operations through spillway weirs and normal spillbays have ceased at this time of year and these fish have only turbine routes available for downstream passage. Water flows are at their lowest at this time of year and can be as low as 20 kcfs in the Snake River. Using this water for spillway weir operation can take a large portion of remaining water flows. Spillway weir notch gates use about one quarter the flow of normal weirs and allow the weir to continue operating at very low flows. However, additional design modifications to the existing weir may be required to avoid the potential for additional injuries from adult sized fish impacting the concrete chute of the spillway.

Fallback rates and passage blockages/delays of adult salmon and steelhead may increase under MO4. Fallback has been associated with higher flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). Increased travel time of adults between Lower Monumental and Lower Granite Dams caused by blocked or delayed adult passage has been consistently observed when Little Goose spill percentages are above 30 percent. It is important to note that regional managers attempt to use in-season adaptive management to identify and remedy any excessive fallback or delays in passage. The effect of TDG on adult salmon and steelhead was not modeled for MO4, but an increase in reach average exposure to TDG is anticipated relative to the No Action Alternative.

Temperatures in the lower Snake River and the lower Columbia River would be similar to the No Action Alternative. In the Columbia River, a general analysis indicated the overall number of days water temperatures in the McNary tailrace that exceed 20°C would not change relative to the No Action Alternative. A site- and timing-specific analysis of water temperature model results indicates slightly warmer conditions in July of low water years, when temperatures would be most stressful to fish. At McNary Dam, outflow temperature would exceed 20°C in 57 days of low flow, high temperature year types (years like 2015), compared to 22 days in the No Action Alternative. Furthermore, the number of days that adult ladder temperature differentials exceed 2 degrees Celsius would slightly increase from 2.8 percent (No Action Alternative) to 3.8 percent (MO4), which may slightly increase delay in dam passage for adult fish (Caudill et al. 2013).

In the balance between survival benefits of transporting juvenile fish with increasing the speed and survival of in-river fish, MO4 is expected to result in less transport and increased numbers of juveniles migrating in-river. This has the potential to shift the overall benefits to abundance of returning salmon and steelhead. This would depend on the degree to which decreased latent mortality would improve ocean survival of in-river fish. Based on the timing of when transported smolts reach the ocean compared to their in-river counterparts, NWFSC modeling predicts increased ocean survival for earlier arriving fish. Since more smolts would travel in-river and arrive below Bonneville Dam later compared to the No Action Alternative, the NMFS COMPASS and LCM models show generally lower abundances of returning Snake River adults without adding any factor for latent mortality. Adult returns to the Snake River are predicted by the NMFS models to be lower for spring migrating stocks unless ocean survival can be increased by 10 percent or more (i.e. a 10 percent or greater reduction in latent mortality). In contrast, CSS modeling predicts increased survival of juvenile salmon and steelhead moving downstream, as well as increased ocean survival, and therefore more returning adults. If CSS model predictions are accurate, SARs and adult abundance would be higher than the No Action Alternative. See the "Comparison of COMPASS and CSS Models" discussion in section 3.5.3.1 for more detail on the two models.

***Upper Columbia River Salmon and Steelhead***

Upstream of McNary Dam, upper Columbia salmon and steelhead migrate past as many as five non-federal dams and reservoirs, which also impact the survival and passage of these species. The federal agencies do not dictate generation or spill levels at the PUD projects so metrics such as powerhouse encounter rate are not directly affected but are influenced by river flow levels coming through the upper Basin. The timing and volume of flow levels affected by CRS operational decisions are reflected in model analysis. COMPASS and LCM estimates of powerhouse encounter rate and SARs include passage effects from a combination of federal and PUD dam passage (Rock Island Dam to Bonneville Dam). CSS model results are not available for upper Columbia stocks.

<u>Upper Columbia Spring-Run Chinook Salmon</u>

*Summary of Key Effects*

Structural and operational measures in MO4 are expected to increase juvenile survival of upper Columbia River spring-run Chinook salmon by 1.5 percent. Travel time and powerhouse encounters would be decreased, but increased exposure to TDG could offset some of the survival improvement. Adult upstream migrants could see additional delays and increased fallback with higher spill as well as increased TDG levels. Life cycle modeling indicated about a three percent increase in abundance. Increases could be higher if lower powerhouse encounters were to decrease delayed mortality in the ocean.

*Juvenile Fish Migration/Survival*

Juveniles in this ESU migrate through the Columbia River downstream past the four lower CRS projects in addition to up to five non-federal dams. Structural and operational measures described in the Common Effects section that describe changes from the No Action Alternative at McNary, John Day, The Dalles, and Bonneville Projects would apply to these fish. Based on the combination of structural improvements, higher spill, and reservoir drawdowns, COMPASS modeling estimates that MO4 is expected to result in a 1.5 percent increase in average juvenile survival for upper Columbia River spring-run Chinook salmon. Relative to the No Action Alternative, a 13 percent decrease in average juvenile travel time from McNary to Bonneville Dam, and a 23 percent decrease in the number of powerhouse passage events from Rock Island to Bonneville Dam (includes passage past three non-federal dams). TDG exposure would be higher for upper Columbia River spring-run Chinook salmon with reach average exposure nearly 120 percent TDG. Increased mortality due to TDG could offset some of the increase in overall juvenile survival from operations and configurations under MO4. CSS cohort modeling for upper Columbia River spring-run Chinook was not available for this ESU. Table 3-92 displays a summary of these model metrics.

Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these predators would likely increase predation on juvenile Chinook and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish

**Table 3-92. Multiple Objective Alternative 4 Juvenile Model Metrics for Upper Columbia River 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% |

*Adult Fish Migration/Survival*

Neither of the adult structural measures in MO4 would provide benefits to upper Columbia River spring-run Chinook salmon because they are both in the Snake River basin. Increased spill and higher TDG in the lower Columbia River would likely reduce adult migration success to some extent.

NWFSC LCM results predict abundance of the Wenatchee population, indicative of this ESU, would increase about 3 percent, assuming latent mortality was the same as in the No Action Alternative. CSS modeling was not available for this population, but the methods in CSS modeling suggest that fewer powerhouse encounters would reduce latent mortality and can be considered here. If the 23 percent lower powerhouse encounter rate were to reduce latent mortality and subsequently increase ocean survival, abundance could increase by more than 3 percent. See Table 3-93 for details.

**Table 3-93. Model Metrics Related to Adult Survival and Abundance of Upper Columbia River 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% | +.02% | +2% |
| Abundance of Wenatchee population, representative of the upper Columbia River Spring Chinook salmon ESU (NWFSC LCM)[1] | 498 | 513 (0%)<br>673 (10%)<br>901 (25%)<br>1308 (50%) | +15 (0%)<br>+175(10%)<br>+403 (25%)<br>+810 (50%) | +3% (0%)<br>+35% (10%)<br>+81% (25%)<br>+163% (50%) |

[1] NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARS or abundance output. For discussion purposes, potential increases in ocean survival of 10 percent, 25 percent, and 50 percent are shown. The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if changes in the alternative were to decrease latent mortality by that much.

Upper Columbia River Steelhead

*Summary of Key Effects*

Measures in MO4 may result in a negligible increase in average juvenile survival for upper Columbia River steelhead, no change in average juvenile travel time, and a 15 percent decrease in the number of powerhouse passage events from McNary to Bonneville Dam. Exposure to TDG would be higher than the No Action Alternative. Similar numbers and arrival timing of juveniles to the ocean, coupled with increased survival of upstream migrants, would likely result in similar abundances of returning adults. If latent mortality in the ocean were to decrease due to fewer powerhouse encounters, there could be a higher increase in abundance.

*Juvenile Fish Migration/Survival*

Juveniles from this DPS migrate through the Columbia River downstream past the four lower CRS projects in addition to up to five PUD dams. Operations at upstream reservoirs that affect seasonal flow patterns downstream influence travel time and survival at the PUD owned projects. Structural and operational measures described in the Common Effects section, including Additional Powerhouse Surface Passage at McNary and John Day and increased spill, would route more fish away from powerhouse routes and likely increase survival. COMPASS modeling estimates predict that from McNary Dam to Bonneville Dam, juvenile survival would increase by 0.3 percent and that travel time would be the same as the No Action Alternative. Powerhouse passages from Rock Island to Bonneville would decrease 15 percent, but TDG exposure would be increased to nearly 120 percent average exposure throughout juvenile migration. Table 3-94 summarizes juvenile model metrics for MO4.

Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Steelhead are particularly susceptible to predation by Caspian terns. Increases in these predators would likely increase predation on juvenile steelhead and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish.

**Table 3-94. Multiple Objective Alternative 4 Juvenile Model Metrics for Upper Columbia River 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% |

*Adult Fish Migration/Survival*

Steelhead that go past their natal (birth) stream typically move downstream in October through March before the start of spring spill, while steelhead kelts move downstream throughout spring, both before and after the start of spill. Adults passing downstream after the start of spill are expected to have a slightly decreased rate of powerhouse passage events. In an adult passage study at McNary Dam, survival rates through turbines at McNary Dam averaged 90.7 percent while survival through the spillway weir averaged 97.7 percent (Normandeau 2014). Steelhead are typically surface oriented and when a surface weir is available, a large fraction of adult migrants use the route (Ham et al. 2012).

Life cycle abundance modeling was not available for upper Columbia River steelhead. However, insights from both the CSS and NWFSC LCM models can be considered when evaluating potential affects to abundance. The NWFSC LCM relies heavily on date of arrival below Bonneville Dam to estimate ocean survival and does not initially consider any increases or decreases in latent mortality. Based on COMPASS modeling, travel time and juvenile survival would be similar to the No Action Alternative, meaning a similar number of juveniles would arrive at the ocean with timing similar to the No Action Alternative. Because arrival timing would be similar, adult abundance could also be similar to the No Action Alternative.

Haeseker et al. (2018) evaluated natural origin steelhead populations from the Entiat and Methow using CSS Snake River steelhead relationships, based on the CSS finding that upper Columbia River steelhead populations have similar responses to fresh water migration conditions (powerhouse passage experiences, flow) and marine conditions as their Snake River counterparts (DeHart 2019/CRSO-47). While their analysis did not model all the MO4 measures, spill to 125 percent TDG at the four lower Columbia projects was estimated to produce a 3.7 percent SAR for the Entiat/Methow steelhead (personal communication, DeHart 2019). The increased SAR was a 28 percent increase relative to the baseline condition[5] used by CSS modelers (Haeseker et al. 2018; DeHart 2019/CRSO-47), which may be similar to the No Action Alternative. Presumably, this increase would be a result of decreased latent mortality in the ocean.

<u>Upper Columbia River Coho Salmon</u>

See Upper Columbia spring-run Chinook salmon analysis as a surrogate for juvenile Upper Columbia coho salmon and Upper Columbia fall Chinook salmon analysis as a surrogate for adult Upper Columbia coho salmon.

*Summary of Key Effects*

Juvenile upper Columbia River coho survival would be similar to upper Columbia River spring-run Chinook, with structural measures and spill increases potentially increasing juvenile survival. Conditions for upstream migrating adults would include similar thermal regime, though higher temperature differential in fish ladders could hamper migration success. Overall, increases in juvenile survival and potentially higher survival due to lower powerhouse encounters and shorter travel times may result in higher returns of adult upper Columbia River coho salmon.

*Juvenile Fish Migration/Survival*

See upper Columbia River juvenile spring Chinook MO4 analysis for surrogate information of juvenile upper Columbia River coho salmon.

Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these predators would likely increase predation on juvenile coho and reduce survival of these fish.

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[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.

The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish

*Adult Fish Migration/Survival*

Adult migration conditions would be similar to upper Columbia River Fall Chinook salmon, which were analyzed in a workshop using water quality and hydrology outputs. MO4 water quality modeling showed no change in the frequency of water temperatures exceeding 20°C relative to the No Action Alternative, when adult upper Columbia coho salmon would be migrating upstream. Upper Columbia River coho adults migrate August/September (early run) and October/November (late run). McNary Dam outflows would be 5 to 10 percent lower than the No Action Alternative in September and October. See upper Columbia River Fall Chinook for surrogate information of adult upper Columbia coho salmon.

<u>Upper Columbia River Sockeye Salmon</u>

Refer to the upper Columbia River Chinook salmon analysis as a surrogate for Upper Columbia River sockeye salmon.

*Summary of Key Effects*

The changes with the greatest effect in MO4 would be the increase in TDG and minor increases in water temperature on dry years when augmentation flows are depleted. Both of these changes would have adverse effects on adult upstream migrating fish survival.

*Juvenile Migration/Survival*

Operational changes for MO4, would increase the number of days with TDG over 120 and 125 percent at Bonneville and McNary dams, but no difference at Chief Joseph Dam. This change is substantial enough that MO4 could have greater adverse effects from TDG compared to the No Action Alternative. Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia River sockeye salmon juvenile and adult fish migration and survival metrics.

Table 3-95 shows the comparison between MO4 and the No Action Alternative of percent of days with TDG over 120 and 125 percent. These increases could cause an increase in occurrence of GBT for juveniles and adults.

**Table 3-95. Percent of Days with TDG above 120 Percent and 125 Percent in the No Action 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 |

Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these predators would likely increase predation on juvenile sockeye and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would, therefore, have no difference in the risk of predation from other fish.

*Adult Migration/Survival*

Neither of the adult structural measures in MO4 would provide benefits to upper Columbia River sockeye salmon because they are both in the Snake River basin. Increased spill and higher TDG in the lower Columbia River would likely reduce adult migration and success to some extent. Refer to the upper Columbia River Chinook salmon analysis, as a surrogate for Upper Columbia River sockeye salmon, for additional information in modeled adult fish migration and survival metrics.

MO4 would result in increased temperatures in July of low-flow years from Chief Joseph Dam to McNary Dam. For upper Columbia River sockeye, a ten percent increase (25 to 35 percent) in the number of days over 18°C at Chief Joseph Dam was noted. This increase would induce thermal stress for upstream migrating adult sockeye. The water temperature at Chief Joseph Dam influences sockeye that use the nearby tributary of Okanogan River. Okanogan sockeye arrive at the confluence of the Okanogan River with the Columbia River when water temperatures are warmer than 21°C, and then hold in the mainstem Columbia River. From around July 1 until the end of August, sockeye hold in the mainstem of the Columbia River until they get a temperature break in the Okanogan River and are then able to move upstream toward their spawning areas. Earlier runs of fish are more successful. The experience of moving up through warm water in the Columbia River, then warm water at the confluence of the Okanogan River Confluence where they hold, means that the cumulative stress is likely to decrease adult fish survival and their gamete viability.

Increased returns of adults would be expected at Bonneville Dam from the increased juvenile survival, which would result in more juveniles arriving to the ocean. Challenges to upstream migration and survival could decrease those gains to some extent, but life cycle modeling was not completed for sockeye salmon. Furthermore, MO4 could provide potential increases of upper Columbia River sockeye salmon abundance if lower powerhouse encounter rates were to increase ocean survival compared to the No Action Alternative.

<u>Upper Columbia summer/fall-run Chinook salmon</u>

*Summary of Key Effects*

Overall, there may be a decrease in reservoir habitat supporting upper Columbia summer/fall-run Chinook salmon, but the magnitude of this decrease is uncertain. There may be slightly greater adult migration delay due to slightly higher incidence of adult ladder temperature differentials above $2^{o}C$.

*Juvenile Fish Migration/Survival*

No change is anticipated in McNary and John Day Reservoir plankton communities or juvenile rearing habitat below Bonneville Dam under MO4, relative to the No Action Alternative (see Section 3.4, *Water Quality*, and the Resident Fish subsection of Section 3.5.2.5 for additional information). However, shoreline habitat in the John Day pool is expected to decrease relative to the No Action Alternative due to the drawdown measures. Overall, there may be a decrease in reservoir habitat supporting upper Columbia summer/fall-run Chinook, but the magnitude is uncertain.

Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these predators would likely increase predation on juvenile Chinook and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish

*Adult Fish Migration/Survival*

As described in common effects, water temperatures in the Columbia River from Chief Joseph to McNary Dam may be warmer than the No Action Alternative in hot, dry years, resulting in additional migration delay, fallback, or susceptibility to disease. The number of days that adult ladder temperature differentials exceed 2°C would slightly increase from 2.8 percent (No Action Alternative) to 3.8 percent (MO4), which may slightly increase delay in dam passage for adult fish (Caudill et al. 2013).

Specific to Okanogan upper Columbia summer/fall-run Chinook, there is a slight increase in number of days the mainstem would be 20°C or higher at the confluence of the Okanogan River (1.1 percent), relative to the No Action Alternative (0 percent) when adults hold in the mainstem. This means that there may be a slight decrease anticipated in the ability of the Okanogan fish to hold in the mainstem until water temperatures in the Okanogan River are cool enough that adults can move up from the mainstem without having to migrate through water temperatures typically considered lethal for salmon and steelhead (Ashbrook et al. 2009).

The frequency of meeting the Vernita Bar Agreement to protect the prolific fall-run Chinook spawning in and around the Hanford Reach of the Columbia River in Washington is not expected to change under any MOs relative to the No Action Alternative. Other operational changes under MOs are likewise not anticipated to affect upper Columbia summer/fall-run Chinook spawning from the tailrace of Chief Joseph Dam to Bonneville Dam in terms of changes in flows, water temperatures, or TDG generated under the MOs.

***Middle Columbia River Salmon and Steelhead***

<u>Middle Columbia River Chinook Salmon</u>

See Upper Columbia River spring-run Chinook analysis as a surrogate for Middle Columbia River Spring-Run Chinook Salmon.

*Summary of Key Effects*

Using the surrogate species of upper Columbia River spring-run Chinook salmon, MO4 may result in minor increases in middle Columbia River Chinook salmon average juvenile survival from the McNary Dam to the Bonneville Dam tailrace, reduce travel times, and decrease the average number of powerhouse passage events. Other effects of MO4 are similar to those generally seen across all salmonids, and are discussed in the *Effects Common Across Salmon and Steelhead* under Section 3.5.3.7.

*Juvenile Fish Migration/Survival*

Under MO4, CRS operational changes may result in increased survival, lower travel times, and decreased powerhouse passage events on juvenile middle Columbia River Chinook. See Upper Columbia River spring-run Chinook analysis as a surrogate for juvenile Middle Columbia River Spring-Run Chinook Salmon.

Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in these predators would likely increase predation on juvenile Chinook and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish

*Adult Fish Migration/Survival*

Effects to middle Columbia River Chinook salmon would be similar to upper Columbia River spring-run Chinook salmon, except they would not experience the increased temperatures in the upper Columbia River reach between Chief Joseph Dam to McNary Dam. Water quality modeling indicated this temperature effect would be attenuated by the time the water would get to McNary Dam, where temperatures would be similar to the No Action Alternative. Increased juvenile survival and shorter travel times would likely result in better ocean survival and more returning adult fish. Further improvements could be realized if lower powerhouse encounter rates were to decrease ocean mortality even further. See Upper Columbia River spring-run Chinook analysis as a surrogate for adult migration and survival of Middle Columbia River Spring-Run Chinook Salmon.

<u>Middle Columbia River Steelhead</u>

Refer to Upper Columbia River steelhead analysis as a surrogate for Middle Columbia River steelhead.

*Summary of Key Effects*

Juvenile survival of middle Columbia River steelhead would increase slightly, though travel time would be similar to the No Action Alternative. Fewer powerhouse encounters would be expected for these fish. A notched spillway weir and higher spill considered in MO4 would increase kelt survival, but higher spill would decrease upstream migrant success. Overall, similar or higher returns of middle Columbia River steelhead would be expected.

*Juvenile Fish Migration/Survival*

Under MO4, CRS operational changes would result in minor increases in juvenile survival, negligible reductions in travel times, and decreased powerhouse passage events on middle Columbia River steelhead. Powerhouse encounters would likely be lower due to increased spill and other measures, as described in Common Effects. Refer to Upper Columbia River steelhead analysis as a surrogate for Middle Columbia River steelhead.

Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Steelhead are particularly susceptible to predation by Caspian terns. Increases in these predators would likely increase predation on juvenile steelhead and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish

*Adult Fish Migration/Survival*

The addition of a notched spillway weir at McNary Dam with 2 kcfs of spill in October and November should increase survival of steelhead for the portion that pass McNary Dam and fallback in the fall. See the common effects section for more details. Increased spill would increase survival of kelts in the spring as well, but may increase straying and fallback of upstream migrants. Refer to Upper Columbia River steelhead analysis as a surrogate for Middle Columbia River steelhead for additional information.

Life cycle abundance modeling was not available for steelhead. However, insights from both the CSS and NWFSC LCM models can be considered in discussing abundance, as described for upper Columbia River steelhead.

***Snake River Salmon and Steelhead***

<u>Snake River Spring/Summer-Run Chinook Salmon</u>

*Summary of Key Effects*

The COMPASS and CSS modeling results predict that compared to the No Action Alternative, juvenile survival rates associated with MO4 from the lower Snake River to below Bonneville Dam would increase, though the magnitudes varied from less than one percentage point to almost 6 percent, depending on the model. Relative to the No Action Alternative, travel time would decrease between eight to 14 percent. The most notable changes would be about an 80 percent relative reduction in powerhouse encounter rates, a major reduction in proportion of fish transported, and TDG exposure of almost 120 percent average through a smolt’s migration.

Adult passage impacts such as fallback or passage delays like those observed at Little Goose dam at spill levels greater than 30 percent could increase under MO4. Adults migrating upstream would also experience substantially elevated average TDG levels compared to the No Action Alternative.

The resulting predicted change in SARS and abundance depends on model assumptions and drivers. The two models used in this analysis predict significantly different smolt-to-adult return rates in the absence of latent mortality. NWFSC LCM predicted a decrease in SARS and abundance if latent mortality was the same as in the No Action Alternative. If decreased powerhouse encounters were to decrease latent mortality by more than 10 percent and therefore increase ocean survival, the SARS and abundance would show an increase. CSS predicts major increases in both SARS and abundance. The two models also predict significantly different smolt-to-adult return rates.

*Juvenile Fish Migration/Survival*

This ESU migrates through the Snake and Columbia Rivers downstream past the eight CRS projects, four on the Snake River, and four on the lower Columbia River. Structural and operational measures described in the Common Effects section that describe changes at all of these dams would apply to these fish.

MO4 would result in an increase in spill, a minor decrease in travel time; a reduction in the proportion of fish going through powerhouses at the projects, fewer juvenile Chinook salmon transported and increased juvenile in-river survival. Increased augmentation flows under MO4 are expected to result in a slightly faster migration times for juvenile Chinook in low water years.

For Snake River spring/summer-run Chinook salmon, the COMPASS model estimates that MO4 would increase juvenile survival from Lower Granite dam to Bonneville Dam by less than one percent, and travel time would decrease by a day and a half (eight percent relative reduction). CSS modeling predicts a larger improvement, with survival 5.9 percent higher and travel time 14 percent lower. However, high spill levels (especially during low river flow conditions) can create large and persistent eddies downstream of each dam. These eddies can adversely affect downstream travel time and in-river survival and are not accounted for in the models during low flow conditions. Consequently, to some degree both models may have the potential to overestimate improvements in juvenile survival, travel time, and SARs.

Data suggests that juvenile Snake River Chinook salmon are migrating earlier in the season with some fish migrating as early as mid-March (DART 2020). Under MO4, spill would begin on March 1st to encompass these early migrants. However, current models are not calibrated to this early spill date and effects from early spill are as yet uncertain. Early spill could benefit early migrants by reducing migration delays and improving survival but river conditions in March can be very different that April and May (lower flows, cooler water temperature). The effects of spill may be much different in early spring compared to later.

Both models predict that the combination of structural measures, increased spill, drawing down the lower Columbia River reservoirs to MOP, and additional flow augmentation in this alternative would be expected to decrease powerhouse encounters. The models predict a decrease in powerhouses encounters that range from 78 percent (COMPASS) to 84 percent (CSS) relative to the No Action Alternative. Spill levels in MO4 lead to increased exposure to TDG, which would increase from about 115 percent up to 120 percent average exposure to a smolt during outmigration. Both models also predict a substantial decrease in the number of smolts transported each year. These changes in TDG exposure and reduced transport could offset some of juvenile survival and life cycle benefits gained with higher spill.

For Snake River spring/summer-run Chinook salmon, the COMPASS and CSS models estimate that MO4 would have the following effects compared to operations under the No Action Alternative, described below in Table 3-96.

**Table 3-96. Multiple Objective Alternative 4 Juvenile Model Metrics for Snake River 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% |

Several measures in MO4 affect juvenile Snake River spring/summer-run Chinook fish transportation rates. The higher spill in MO4 would substantially decrease the proportion of smolts transported during the spring spill season because fewer fish would be passing through the juvenile fish bypasses (a higher proportion would pass via spillways) and thus not available for transport. Juvenile fish transportation would be suspended on June 14 through August 15, then reinitiated and continued through November 15. Stopping transport in mid-June may affect the tail end of the Snake River spring/summer-run Chinook outmigration. Although there may be few fish still migrating downstream, late spring benefits from transportation are typically high, so this could lower juvenile migration success for those late migrating spring Chinook. The re-initiation of juvenile fish transportation after mid-August would occur after the Snake River spring/summer-run outmigration has ended and is not anticipated to affect this ESU. The life cycle implications of these juvenile experiences are discussed further in adult survival.

The proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in bird predators could increase predation on juvenile fall Chinook salmon and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish.

*Adult Fish Migration/Survival*

Several structural measures in MO4 are anticipated to benefit adult Snake River spring/summer-run Chinook passage upstream and these include: modifying the adult trap and bypass loop at Lower Granite dam reducing delay) and installing pumping systems at Ice Harbor and Lower Monumental ladders to reduce ladder temperature differentials if cool water is available in order to reduce delay.

However, fallback rates, as well as passage delay or blockage, of Snake River spring/summer-run Chinook may increase under MO4. Fallback for this ESU has been associated with higher flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). The fish that fell back were less likely to reach their spawning areas compared to fish that never fell back. When looking at PIT-tag data from Bonneville Dam during 2006–2011, a mean of 9.6 percent of spring/summer-run Chinook salmon that fell back reascended (NMFS 2019). Thus, the MO4 higher spill operation would increase the fallback of Snake River spring/summer-run Chinook salmon adults as they migrate upstream.

Adult passage delay and/or blockages may also increase under MO4. Substantial delays and decreases in adult passage rates at Little Goose have been frequently observed when spill levels exceed proportions greater than 30 percent of total river flow. This challenge could occur at other projects under the spill levels that would be implemented as part of MO4. Other operational effects discussed in common effects would also apply to this ESU. It is important to note that regional managers use in-season adaptive management to identify and remedy any excessive fallback or delay. Therefore, while the average survival for Snake River spring/summer-run Chinook salmon adults may decrease from the recent averages of about 89 percent between Bonneville and McNary Dam, and 84 percent between Bonneville and Lower Granite Dam under the No Action Alternative, increased challenges with adult passage may or may not have a large effect under this alternative.

Due to differing assumptions and drivers in the models, and possibly also due to the different populations modeled, the primary life cycle models produced widely differing results for Snake River spring/summer-run Chinook salmon SARS and abundance. The NWFSC LCM indicated a 12 percent decrease in SARS and an average 32 percent decrease in abundance of adult returns to spawning grounds relative to the No Action Alternative. CSS, on the other hand, predicts MO4 would increase SARS by 75 percent and nearly double the abundance of adult returns. These metrics are displayed in Table 3-97.

**Table 3-97. Multiple Objective Alternative 4 Adult Model Metrics for Snake River Spring/Summer-Run Chinook Salmon**

| Metric (Model) | NAA | MO4 | Change from NAA | % Change |
|---|---|---|---|---|
| LGR-BON SARs (NWFSC LCM)[1] | 0.88% | 0.77% (0%)<br>0.84% (10%)<br>0.94% (25%)<br>1.12% (50%) | -0.11% (0%)<br>-0.04% (10%)<br>+0.06% (25%)<br>+2.4% (50%) | -12% (0%)<br>-4% (10%)<br>+8% (25%)<br>+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%)<br>1,944 (10%)<br>2,489 (25%)<br>3,586 (50%) | -761 (0%)<br>-407 (10%)<br>+138 (25%)<br>+1,235 (50%) | -32% (0%)<br>-17% (10%)<br>+6% (25%)<br>+53% (50%) |
| Abundance (CSS)[2] | 6114 | 12159 | +6045 | +99% |

[1] NWFSC LCM does not factor latent mortality due to the hydrosystem into the SARS or abundance output. For discussion purposes, potential increases in ocean survival of 10 percent, 25 percent, and 50 percent are shown. The value for 0 percent is the actual model output, the 10 percent, 25 percent, and 50 percent values represent scenarios of what SARs, or abundance hypothetically could be under the increased ocean survival if changes in the alternative were to decrease latent mortality by that much.

[2] CSS provided results for six populations in the Grande Ronde/Imnaha Major Population Group. The absolute values represent those populations only; the percent change is considered indicative of the Snake River ESU for the purpose of comparing between MOs.

The differences in model assumptions and the results returned can lend additional understanding to MO4 effects on Snake River spring/summer-run Chinook salmon, as well as infer understanding of other ESU/DPSs of salmon and steelhead as well.

The CSS model predicts that in-river survival of juvenile spring Chinook salmon will increase above a threshold of roughly 60 percent, which is the point where the model predicts that transportation no longer provides a benefit compared to in-river migration. Because average survival is expected to be 63.5 percent, CSS results predict that reduced latent mortality more than offsets the reduction in the number of transported fish and therefore predicts major improvements in the abundance of returning Snake River spring Chinook salmon.

The NMFS LCM uses input metrics from COMPASS results, such as juvenile survival and travel timing. The ocean survival of fish that survive to below Bonneville Dam are then estimated by a separate ocean model. The LCM model then uses an adult migration module based on adult fish returning from the ocean and have reached Bonneville Dam, and then computes expected survival for migration upstream to spawning grounds in the upper Snake River Basin.

It is important to note that the juvenile survival indicated in the COMPASS metrics in the juvenile survival table applies to in-river traveling smolts only. Based on prior research, transported smolts are assumed to have a survival rate of 98 percent from Lower Granite to Bonneville Dam, compared to roughly 50 percent survival of in-river smolts. MO4 spill levels reduce the proportion of transported fish and increase the number of smolts experiencing the lower survival rate of the in-river travel. In-river migrants typically arrive below Bonneville Dam later than transported fish, which can decrease ocean survival in the model. The result would be fewer juveniles make it to the ocean under optimal timing resulting in lower overall survival to adulthood. There are also seasonal changes to the relative effect of transport each year. Generally-speaking, fish transported later in the spring season experience better SARs than in-river fish, while earlier in the season there is more benefit to in-river travel. This could be driven by challenges to in-river survival due to factors such as predation and thermal stress, which tend to increase from April to June. MO4 would cease transport in mid-June, when the survival benefit of being transported would be greatest. The lower rate of transported smolts could result in fewer adults straying to different populations than their origin.

Another difference between the models is how ocean survival is accounted for. CSS models incorporate data that links increases or decrease in ocean survival to the hydrosystem experience of each smolt (i.e. latent or delayed mortality from CRS passage is expressed in changes to ocean survival). For MO4, ocean survival was predicted to increase from 3.6 percent under the No Action Alternative to 5.7 percent in MO2 (a 60 percent increase in ocean survival). Factors such as fewer powerhouse encounters and decreased travel time are assumed to increase survival in the ocean due to decreased latent mortality from a smolt's experience through the CRS projects, which would in turn increase the abundance of returning adults to the Columbia River.

While ocean survival is not directly tied to the CRS passage experience in the NMFS LCM models, as a sensitivity analysis, factors of potential change in ocean survival were applied to the results. The model predicts an abundance increase under MO4 if ocean survival can be increased by more than 10 percent. The model run with increased ocean survival of 50 percent indicates an increase of 53 percent more adults than the No Action Alternative. However, the LCM model runs predict that if latent mortality is not reduced by more than 10 percent than the measures associated with MO4 would lead to a decrease in SARS for Snake River spring Chinook salmon and reduced adult abundance of the South Fork Salmon and Middle Fork Salmon River representative populations.

<u>Snake River Steelhead</u>

*Summary of Key Effects*

Both models indicate moderate improvement to the juvenile metrics of survival, travel time, and powerhouse passage events, though the magnitude of estimated survival varies. The two models also predict significantly different smolt-to-adult return rates.

*Juvenile Fish Migration/Survival*

This ESU migrates through the Snake and Columbia Rivers downstream past the eight CRS projects, four on the Snake River, and four on the lower Columbia River. MO4 would result in a substantial increase in spill, a decrease in travel time, a reduction in the proportion of fish going through powerhouses at the projects and fewer juvenile steelhead transported. Increased augmentation of river flows under MO4 are expected to result in a slightly faster migration times for juvenile steelhead in low water years.

Structural and operational measures described in the Common Effects section that describe changes at all of these dams would apply to these fish. The combination of several measures is predicted to decrease travel time and powerhouse encounters, as well as increase survival. This includes a measure to increase Columbia River flows on dry years downstream of Chief Joseph Dam. COMPASS modeling indicates 0.4 percent increase in average juvenile Snake River steelhead survival; whereas CSS indicates the increase would be 16.6 percent, a major increase in survival (30 percent improvement relative to the No Action Alternative). Both models agree travel time would decrease by approximately a day and a half (8 percent (COMPASS) to 10 percent (CSS) reduction relative to the No Action Alternative). However, high spill levels (especially during low river flow conditions) can create large and persistent eddies downstream of each dam. These eddies can adversely affect downstream travel time and in-river survival and are not accounted for in the models during low flow conditions. Consequently, both models may overestimate improvements in juvenile survival, travel time, and SARs.

There is evidence that juvenile Snake River steelhead are migrating earlier in the season with some fish migrating as early as late March (DART 2020). Under MO4, spill would begin on March 1st to encompass these early migrants. However, current models are not calibrated to this early spill date and effects from early spill are as yet uncertain. Early spill could benefit early migrants by reducing migration delays and improving survival but river conditions in March can be very different that April and May (lower flows, cooler water temperature). The effects of spill may be much different in early spring compared to later.

The combination of structural measures, increased spill, drawing down the lower Columbia River reservoirs to MOP, and additional flow augmentation in this alternative would be expected to decrease powerhouse encounters. The models predict a decrease of 80 percent (COMPASS) to 86 percent (CSS) relative to the No Action Alternative. While powerhouse passage is expected to decrease, exposure to TDG would increase from about 115 percent up to 120 percent average exposure to a smolt during outmigration. This exposure could potentially offset some of juvenile survival and life cycle benefits gained. The COMPASS model also predicts a substantial decrease in the number of smolts transported each year. Table 3-98 displays the juvenile model metrics for Snake River steelhead under MO4.

**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% |

Several measures in MO4 would affect juvenile Snake River steelhead transportation rates. Juvenile fish transportation would be suspended on June 14. This may affect the tail end of the juvenile Snake River steelhead outmigration. Early season transport is most beneficial for steelhead, particularly for natural origin steelhead (Gosselin et al. 2018). Because over 95 percent of the Snake River steelhead DPS has passed McNary Dam before mid-June (DART) reducing transport on June 14 should not decrease these benefits. The re-initiation of juvenile fish transportation from August 16 to November 15 would be after the juvenile Snake River steelhead outmigration and is not anticipated to affect this DPS.

The higher spill in MO4 would substantially increase the number of juveniles passing via spillways and thus not able to be collected in juvenile fish bypasses for transport. COMPASS modeling predicts transportation would change from an average of 40 percent of the wild fish transported under the No Action Alternative to about 7 percent under MO4, an 82 percent relative decrease. The proportion transported in any given year could vary with hydrologic and operational conditions. Transported juvenile steelhead have an expected rate of 98 percent survival to below Bonneville Dam compared to the in-river juvenile survival of 43 percent. Because of this survival differential unless significant increases to in-river survival, similar to those predicted by the CSS model, fewer juveniles overall would survive the trip from Lower Granite to Bonneville Dam based on the COMPASS analysis. Further implications of transport are discussed in the Adult Survival section below.

Proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Steelhead are particularly susceptible to predation by Caspian terns. Increases in these predators would likely increase predation on juvenile steelhead and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish.

*Adult Fish Migration/Survival*

Several structural measures in MO4 are anticipated to benefit adult Snake River steelhead passage upstream, including modifying the adult trap and bypass loop at Lower Granite Dam and installing pumping systems at Ice Harbor and Lower Monumental ladders intended to reduce ladder temperature differentials and migration delays. Other operational effects discussed in common effects would also apply to this ESU. Higher spring spill levels should result in higher survival rates for adult steelhead falling back through dams and kelts migrating downstream, as fewer adults used powerhouse passage routes when a spill route was available and overall downstream passage increased when surface passage was available (Normandeau et al. 2014). However, increases in fallback rates, adult passage delay and/or blockages may also increase under MO4 and are generally an adverse impact on adult survival and spawning success. Substantial delays and decreases in adult passage rates at Little Goose have been frequently observed when spill levels exceed proportions greater than 30 percent of total river flow. This challenge could occur at additional projects under the spill levels that are proposed as part of MO4.

Based on CSS model results (see Table 3-99), major increases in adult returns would be expected. For Snake River steelhead, the CSS cohort model predicted that the Lower Granite to Bonneville Dam smolt to adult return rate would be 1.8 percent under the No Action Alternative, and 3.1 percent under MO4. This represents a 72 percent increase in adult returns back to Bonneville Dam per smolt passing Lower Granite Dam. This result assumes that fish passage improvements at the CRS projects will reduce latent mortality affects and improve ocean survival.

**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% |

There are no LCM results for Snake River steelhead but based on NMFS modeling results for Snake River spring Chinook salmon, MO4 may actually result in a major decrease in adult returns of Snake River steelhead compared to the No Action Alternative. As described in the juvenile effects section, transportation rates would be much lower earlier.

Typically, transportation provides a larger benefit to steelhead than spring Chinook. Because, like with spring Chinook, both CSS and COMPASS models predict large declines in transportation, it is reasonable to assume that LCM results would also show a decline in overall SARs in the absence of any latent affects like those predicted by CSS modeling.

<u>Snake River Coho Salmon</u>

See Snake River spring/summer-run Chinook salmon as a surrogate for juvenile Snake River coho salmon and Snake River fall-run Chinook as a surrogate for adult Snake River coho salmon.

*Summary of Key Effects*

Juvenile Snake River coho salmon survival may see a moderate increase in MO4, with faster travel time, lower powerhouse encounters, but higher TDG exposure. The proportion of fish transported would be lower than the No Action Alternative. Structural measures would improve adult upstream migration. The overall abundance of returning adults is uncertain, depending on how lower transport rates, higher in-river juvenile survival, and lower powerhouse encounters interact with ocean survival.

*Juvenile Fish Migration/Survival*

MO4 would result in an increase in spill, a minor decrease in travel time, a reduction in the proportion of fish going through powerhouses at the projects and fewer juvenile coho salmon transported. Increased augmentation flows under MO4 are expected to result in a slightly faster migration times for juvenile coho in low water years.

Structural and operational measures described in the common effects section would apply to juvenile Snake River salmon, and most of these would be expected to increase juvenile survival.

Juvenile survival of Snake River coho salmon is estimated using juvenile modeling results for Snake River spring/summer-run Chinook salmon as a surrogate. See Snake River spring/summer-run Chinook salmon quantitative results as a surrogate for Snake River coho salmon.

The proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in bird predators could increase predation on juvenile fall Chinook salmon and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish.

*Adult Fish Migration/Survival*

Structural measures in MO4 would reduce adult passage delays and increase adult Snake River coho salmon upstream migration success (e.g., modified adult trap and bypass loop at Lower Granite Dam, and pumping systems at Ice Harbor and Lower Monumental ladders to reduce ladder temperature differentials). Changes in fish spill would not affect upstream migration because they migrate after fish spill would end. See adult Snake River Chinook analysis as a surrogate for Snake River coho.

Abundance of returning adults was not modeled for Snake River coho salmon, but some inferences can be made from life cycle modeling of Snake River spring/summer-run and fall-run Chinook salmon. In general, fewer coho salmon would be transported as juveniles in MO4, and more would travel in-river. Based on surrogate results, if decreased powerhouse encounters were to increase ocean survival, there could be a major increase in adults. If ocean survival would not be affected by changes in powerhouse encounters, then abundance could see a moderate decrease due to the overall later arrival of smolts to the ocean.

<u>Snake River Sockeye Salmon</u>

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for Snake River sockeye salmon.

*Summary of Key Effects*

Notable effects of this alternative include increased nesting habitat for birds that puts outmigrating juvenile sockeye at greater risk of predation as well as greater TDG exposure. TDG exposure could be balanced somewhat by the faster travel time that may increase juvenile survival. A major beneficial effect for upstream migrating adults would occur due to much less transport of those fish as juveniles.

*Juvenile Migration/Survival*

MO4 would result in an increase in spill, a decrease in travel time, a reduction in the proportion of fish going through powerhouses at the projects and fewer juvenile sockeye salmon transported. Increased augmentation flows, under MO4, are expected to result in a slightly faster migration times for juvenile sockeye in low water years based on surrogate species, Snake River spring/summer-run Chinook salmon. Additional results for surrogate, juvenile Snake River spring/summer-run Chinook, showed that minor reductions in travel time would occur when compared to the No Action Alternative. Faster travel times generally result in increased survival rates.

The proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in bird predators could increase predation on juvenile sockeye salmon and reduce survival of these fish. The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish.

Operational changes for MO4 would cause a major increase in the number of days with TDG over 120 and 125 percent at Bonneville, McNary, and Lower Granite projects. This change is substantial enough that MO4 could have greater adverse effects from TDG compared to the No Action Alternative. Table 3-100 shows the comparison between MO4 and the No Action Alternative of percent of days with TDG over 120 and 125 percent. This could cause an increase in occurrence of GBT for juveniles and adults.

**Table 3-100. Percent of Days with TDG above 120 Percent and 125 Percent in the No Action 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 |

*Adult Migration/Survival*

Under MO4, downstream transport of juvenile sockeye would be decreased; based on surrogate species, Snake River spring/summer-run Chinook salmon analyses expect major reduction in transportation. Decreased transportation could also result in an overall decrease in the amount of fallback and straying related to transport. Straying may still occur, but would be much closer to the natural levels for this population

Adult sockeye migrate upriver in late summer and early fall when flows are low and water temperatures can be high. High spill levels under these conditions can cause migration delays as fish search for entrances to fish ladders. These delays are expected to occur at Little Goose Dam and may occur at other projects. This population travels far inland and adults have little excess energy reserves for migration. Delays for these fish may reduce fitness and the probability of successfully spawning.

The summer water temperatures in the river during the upstream migration would not change. However, this alternative is estimated to have 58.9 percent of all days with a greater than 2-degree temperature difference between the river and the fish ladders compared to 50 percent of all days in the No Action Alternative. Having substantially more days with a greater than 2-degree temperature differential between river water and the fish ladders would cause a greater risk of delay at the dams. Installation of pumps to provide cool water in the ladders may reduce the number of days with large differentials in temperature.

The increase in TDG could have adverse effects for adult migrating salmon. The other important water quality parameters of suspended sediment and DO would have no change compared to the No Action Alternative.

Abundance of returning adults was not modeled, but some inferences can be made from life cycle modeling of surrogate Snake River spring/summer-run Chinook salmon. Fewer sockeye salmon would be transported as juveniles, and more smolts would travel in-river. Similar to the surrogate species, if decreased powerhouse encounters were to increase ocean survival, there could be a major increase in adults. If ocean survival would not be affected by changes in powerhouse encounters, then abundance changes are much harder to predict for this species.

<u>Snake River Fall-Run Chinook Salmon</u>

*Summary of Key Effects*

The most notable effect of MO4 for Snake River fall-run Chinook would be the risk of delays for adults trying to migrate up the fish ladders. MO4 would have more days with a temperature differential of more than 2 degrees Celsius warmer water in the fish ladders. A minor beneficial effect for upstream migrating adults would be the reduction in straying that could occur because fewer fish would be transported as juveniles.

*Larval Development/Juvenile Rearing*

None of the measures under MO4 would change the substrate sizes or distribution in the spawning areas or expand suitable spawning areas; therefore, this alternative is expected to have the same larval development and juvenile rearing habitat conditions as the No Action Alternative. The same would be true for river depths in the spawning areas; no change is anticipated for eggs incubating in the gravel. Additionally, there would be no change in the reservoirs that provide rearing habitat for overwintering fall-run Chinook.

*Juvenile Migration/Survival*

MO4 would result in an increase in spill, a decrease in travel time, a reduction in the proportion of fish going through powerhouses at the projects and fewer juvenile fall Chinook salmon transported. Increased augmentation flows under MO4 are expected to result in negligible decreases in migration travel times for juvenile fall chinook in low water years.

The proposed MOP operations at projects would reduce pool elevations and increase nesting habitat for Caspian terns and gulls at Blalock Island in the John Day pool. Increases in fish eating birds could increase predation on juvenile fall Chinook salmon and reduce survival of these fish.

The mean water temperature is expected to be the same as the No Action Alternative and would therefore have no difference in the risk of predation from other fish.

Turbidity effects in MO4 would have no expected change relative to the No Action Alternative in the Snake River, but would have effects in the McNary Dam tailrace because of forebay elevation manipulations at John Day Dam. The *Drawdown to MOP* measure may have minor turbidity effects, but effects are not expected to be great in large reservoirs.

Some operations can produce hydraulic conditions within the tailrace that increase fish vulnerability to predation by extending the amount of time they spend in the tailrace. These conditions can also increase the time juvenile fish are exposed to elevated levels of dissolved gas. High spill under MO4 would likely create these conditions at Snake River dams. High spill levels can lead to large eddies and have been known to draw fish from spillway outflow into the slower flows of the powerhouse and circulate them in predator holding areas. These eddies can even pull fish from the bypass facilities into these predator rich areas. Under MO4, juvenile fish would experience an increased risk of predation because of these hydraulic conditions.

The benefits of transport for fall Chinook increase in the summer and fall (Smith et al. 2018). Consequently, the termination of transport from July 1 through August 15 may potentially reduce juvenile survival and adult returns for this species and would require adaptive management.

*Adult Migration/Survival*

Under MO4, downstream transport of juvenile fish would be reduced compared to the No Action Alternative. Because stray rates of transported fish are approximately 5 percent greater than for fish left in river during migration (Bond et al. 2017), there would be a minor decrease in the numbers of fish that stray to other tributaries. Straying may still occur but would be reduced.

River water temperatures during the upstream migration period are expected to be the same as in the No Action Alternative, which would mean the same rate of delay and fallback would continue to occur. Likewise, there would be no change to sediment concentrations or DO levels from any measures in MO4 during the adult migration period.

The temperature differential between the river and the fish ladders would be worse than in the No Action Alternative. MO4 would have 58.6 percent of all days in August and September with more than 2 degree Celsius differential compared to 50.1 percent in the No Action Alternative. This would have a slight increase in risk of delay under MO4 due to approximately five more days with warmer water in the ladders. Installation of ladder cooling pumps at Lower Monumental and Ice Harbor dams would reduce number of days at these dams where temperatures differences between the river and fish ladders would deter migration.

No life cycle modeling is available for Snake River Fall Chinook salmon, but some inferences can be made from life cycle modeling of Snake River Spring/Summer Chinook salmon. Fewer salmon would be transported as juveniles, and more would travel in-river. The relative SAR of transported fall Chinook is on average lower than that of in-river fish in June and early July, while the benefits of transportation on SAR are highest in August and September (Gosselin et al. 2018). Similar to Snake River spring/summer-run Chinook salmon, if decreased powerhouse encounters were to increase ocean survival, there could be a major increase in adults. If ocean survival would not be affected by changes in powerhouse encounters, then abundance could see a moderate decrease due to the overall later arrival of smolts to the ocean. Fewer fish in late transport would result in reduced adult returns.

***Lower Columbia River Salmon and Steelhead***

Lower Columbia River Chinook Salmon

Refer to the Snake River spring/summer-run Chinook salmon analysis as a surrogate for lower Columbia River Chinook salmon.

*Summary of Key Effects*

Juvenile Lower Columbia River Chinook salmon survival would be decreased slightly under MO4 due to modeled conditions such as spill, and likely be further decreased due to exposure to high TDG during outmigration. Adult migration would likely be less successful with increased fallback, delays, and TDG effects.

Results (and change from the No Action Alternative) for metrics for lower Columbia River Chinook salmon:

- Negligible decrease in juvenile project survival at Bonneville Reservoir and Dam (see Snake River spring-run/summer-run Chinook used as a surrogate) = (-0.8 percent)
- Bonneville Dam median outflows, April to June = (0 percent to -2 percent most years)
- Bonneville Dam outflows, August to September = (-4 percent to -7 percent)
- Spill, Bonneville = Spill, Bonneville Dam = March (+71 percent) April-Jul (+10 percent to +26 percent)
- Temperature, The Dalles Dam, days exceeding state standard = 72 days (+1 day)
- Temperature, Bonneville Dam, days exceeding state standard = 57 days (-1 day)
- TDG, The Dalles Dam, days exceeding state standard = 127 days (+94 days)
- TDG, Bonneville Dam, days exceeding state standard = 113 days (+52 days)

*Juvenile Fish Migration/Survival*

Five of the 32 populations of Lower Columbia River Chinook salmon pass Bonneville Dam on their downstream outmigration to the ocean. Modeling was not available for this ESU so juvenile survival at Bonneville Dam of Snake River spring/summer-run Chinook salmon was used as a surrogate of juvenile survival. COMPASS modeling predicts juvenile survival of 88.2

percent through the Bonneville Project, including the reservoir and the dam, or 0.8 percent lower than the No Action Alternative. It is important to note this model result does not incorporate any effects from TDG exposure, which would be much higher in MO4. The number of days that would exceed the state water quality standard for TDG at The Dalles and Bonneville tailwater would be 90 percent and 180 percent higher, respectively.

Outflows can influence juvenile outmigration if changes in flows are enough to noticeably affect travel time, and therefore survival. Increased spill also decreases travel time. Hydrology modeling predicts spring-run and late-fall-run fish would experience outflows about 1 to 2 percent lower in April through August than the No Action Alternative in most years, but flow augmentation in dry years could improve migration speed for the portion of all runs that outmigrate in May and June and sometimes July. Increased spill in April through July would also decrease travel time. Fall-run fish outmigrate in late summer and may see flows up to 4 to 7 percent lower in August through September than the No Action Alternative, but with higher spill. This decrease in late summer flows could affect the ability of these juveniles to outmigrate and use habitats in the estuary. Water quality modeling indicated there would not be a perceptible change in temperature in the lower river with MO4 operations.

*Adult Fish Migration/Survival*

There are no structural measures in MO4 that would increase adult passage and survival. Fallback rates for spring-run would likely increase with higher spill in April under MO4 as fallback is associated with higher flow and higher spill levels at many dams (Boggs et al. 2004; Keefer et al. 2005). However, regional managers use in-season adaptive management to identify and remedy any excessive fallback. Hydrology and water quality modeling predicts flows and temperatures would be similar to the No Action Alternative, except for slightly lower fall flows could increase adult migration of fall-run and late-fall-run fish. Higher TDG described for juvenile fish would also affect adult migrating fish. Although TDG would be higher throughout spring and summer than the No Action Alternative, the biggest difference would be in March and April where TDG would typically be below the state standard in the No Action Alternative (about 112 percent in March) but over 120 percent TDG in MO4. This would increase TDG-related effects to spring-run adults.

Lower Columbia River Steelhead

Refer to Snake River steelhead analysis as a surrogate for lower Columbia River steelhead.

*Summary of Key Effects*

Juvenile Lower Columbia River steelhead survival would be decreased slightly due to modeled conditions such as spill and flows, as well as high TDG. In dry years, juvenile survival would be improved with additional flow augmentation. Adult upstream migration would likely be less successful with increased fallback, delays, and TDG effects; however, kelt survival would be improved with higher spill.

*Juvenile Fish Migration/Survival*

Survival would be decreased slightly due to modeled conditions such as spill, and likely be further decreased due to exposure to high TDG during rearing and outmigration.

MO4 results (and change from the No Action Alternative) for metrics for Lower Columbia River Steelhead:

- Negligible decrease in juvenile project survival, Bonneville Reservoir and Dam (Snake River steelhead used as a surrogate) = (-0.6 percent)
- Bonneville Dam outflows, April to June = (0 percent to -2 percent most years.
- Bonneville Dam outflows, August to October = (-4 percent to -7 percent) otherwise (+/- 0 to 2 percent)
- Spill, Bonneville Dam = March (+71 percent) April-Jul (+10 percent to +26 percent)
- Temperature, The Dalles Dam, days exceeding state standard = 72 days (+1 day)
- Temperature, Bonneville Dam, days exceeding state standard = 57 days (-1 day)
- TDG, The Dalles Dam, days exceeding state standard = 127 days (+94 days)
- TDG, Bonneville Dam, days exceeding state standard = 113 days (+52 days)

Modeling juvenile survival of Snake River steelhead, used as a surrogate for the Lower Columbia River steelhead, through the Bonneville project (reservoir and dam), predicts under MO4 negligible lower survival than the No Action Alternative. Among the fish that pass Bonneville Dam, higher spill in the spring would slightly decreased dam passage survival, although it would also reduce travel time and result in faster transitions through the project area. In dry years, additional flow augmentation would help move juveniles out more quickly than the No Action Alternative. Temperatures would be similar to the No Action Alternative. It is important to note this model result does not incorporate any effects from TDG exposure, which would be much higher in MO4. The number of days that would exceed the state water quality standard for TDG at The Dalles and Bonneville tailwater would be 90 percent and 180 percent higher, respectively. TDG would be higher than the water quality standard for most of the juvenile outmigration season.

*Adult Fish Migration/Survival*

There are no structural measures in MO4 for increased adult upstream passage. Under MO4, higher spill levels during upstream migration periods should result in higher survival rates for adult steelhead falling back through dams and kelts migrating downstream, but may increase fallback and delay of upstream migrants. Lower flows in August through October may increase the migration speed and success of the tail end of the summer run.

Temperatures would be similar to the No Action Alternative, and adult fish would generally experience higher TDG as described for juveniles. Higher TDG described for juvenile fish would affect adult migrating fish as well. Although TDG would be higher throughout spring and summer than the No Action Alternative, the biggest difference would be in March and April where TDG would typically be below the state standard in the No Action Alternative (about 112 percent in March) but over 120 percent TDG in MO4. This would increase TDG-related effects to the winter run. Summer steelhead would experience much higher TDG throughout their upstream migration period.

<u>Lower Columbia River Coho Salmon</u>

See Snake River spring/summer-run Chinook salmon analysis as a surrogate for juvenile Lower Columbia River coho salmon and Snake River fall-run Chinook salmon as a surrogate for adult Lower Columbia River coho salmon.

*Summary of Key Effects*

Overall, a negligible decrease in juvenile passage survival for Lower Columbia River coho is expected due to increased spillway passage and water temperatures under MO4, relative to the No Action Alternative. An increase in fish ladder temperature differentials would also decrease adult migration success.

*Juvenile Fish Migration/Survival*

Lower Columbia River coho salmon passing Bonneville Dam under MO4, based upon project survival of Snake River spring/summer-run Chinook salmon as a surrogate, would result in negligible decreases in survival (approximately 0.9 percent). Refer to Snake River spring-run Chinook for surrogate information in Section 3.5.2.6. Generally speaking, higher spill at Bonneville Dam results may result in lower survival through the dam.

*Adult Fish Migration/Survival*

Lower Columbia River coho salmon adults are similar in upstream migration characteristics to Snake River fall-run Chinook salmon and were used as a surrogate for adult Lower Columbia River coho salmon. Snake River fall-run Chinook salmon were analyzed in workshops using modeled water quality and hydrology data; MO4 operational changes could result in fewer days when lower Columbia water temperatures in reservoirs would exceed 20°C, and water temperatures around Bonneville Dam specifically may be slightly cooler under all of the MOs compared to the No Action Alternative. However, MO4 analysis showed more days when lower Columbia fish ladder temperature differentials would exceed 2 degrees Celsius. This change in ladder temperature differentials may cause an increase in adult salmon to stop or delay migration relative to the No Action Alternative. For additional information on the surrogate species, Snake River fall-run Chinook, refer to Section 3.5.2.5.

<u>Columbia River Chum Salmon</u>

Refer to Snake River spring/summer-run Chinook salmon analysis as a surrogate for Columbia River chum salmon.

*Summary of Key Effects*

MO4 operations would result in more difficulty in meeting chum flows downstream of Bonneville Dam, with an increase of 12 percent of years, compared to the No Action Alternative, where the flows could not be met without additional drafting of Grand Coulee. Juvenile outmigration could be slower due to decreased outflows in March, and the small proportion of juvenile chum salmon that pass Bonneville Dam would experience negligible increased survival at the dam. Adult migration and survival would likely be similar to the No Action Alternative.

MO4 is expected to result in a 1 percent decrease in juvenile chum survival relative to the No Action Alternative from spawning sites directly downstream of Bonneville Dam, with the decision to either abandon chum or draft additional water from Grand Coulee in 20 percent of years. Incubating chum sac fry would be exposed to TDG above 105 percent in 30 out of 80 years, which is higher than the modeled exposure rate in the No Action Alternative (four out of 80 years).

*Larval Development/Juvenile Rearing*

How operations under MO4 affects the ability of Grand Coulee to provide winter flows to protect chum redds and provide sufficient access to habitat was calculated using hydrology modeling. Chum flows may also be impacted by changes to carryover at storage projects and how they impact inflows to Grand Coulee reservoir; the water supply measure will reduce carryover in all years, and the McNary Flow Objective measure will substantially reduce carryover in dry years. Under MO4, chum flows would be met in 80 percent of years, compared to 92 percent of years in the No Action Alternative. In years when additional releases from Grand Coulee for chum would be needed, the average additional volume needed would be 0.24 Maf. This would be a moderate decrease to the success of chum rearing and decision-makers would have to decide whether to increase risk to chum eggs or reduce spring augmentation flows for spring migrating juvenile salmon.

Maintaining water saturation of 105 percent TDG or less from November 1 through April 30303030 appears to provide a sufficient level of protection to chum salmon eggs and sac fry incubating in the gravel downstream of Bonneville Dam in the Ives/Pierce Island Complex. In MO4, chum sac fry would be exposed to TDG above 105 percent in 30 out of the 80-year record modeled, all in the mid- to late April timeframe. This is 25 more years out of 80 (or 31 percent more often) than the No Action Alternative where this TDG threshold would be exceeded.

*Juvenile Fish Migration/Survival*

Chum salmon only encounter one CRS project, Bonneville Dam; therefore, none of the structural measures described in common effects would apply to these fish, and only a small proportion of spawning occurs above Bonneville Dam. As there is no direct estimate of Bonneville Project survival specific to juvenile chum, juvenile model metrics for Snake River spring/summer-run Chinook salmon are used as a surrogate to estimate any change in juvenile survival for the portion that pass Bonneville Dam. Under MO4, COMPASS modeling for the surrogate species indicates that CRS operational changes are expected to result in negligible decreases in juvenile passage survival compared to the No Action Alternative. MO4 would not change the outmigration conditions for juvenile chum that spawn below Bonneville Dam, other than they may experience higher TDG than under the No Action Alternative. Bonneville Dam outflows would be similar to the No Action Alternative when chum juveniles begin outmigration.

*Adult Fish Migration/Survival*

Most chum spawn downstream of Bonneville. Migration of chum into the Columbia River is in October and November. Bonneville Dam average monthly outflows would be about 1 to 3 percent lower than the No Action Alternative and would be a negligible effect on adult migration under MO4.

**Other Anadromous Fish**

***Pacific Eulachon***

<u>Summary of Key Effects</u>

Eulachon would continue to migrate into the Columbia River from November through March, with specific dates of migration and spawning based on a variety of environmental factors including temperature, high tides, and ocean conditions (NMFS 2017). Temperature, spawning locations, and substrate would be the same as the No Action Alternative.

In most water year types, MO4 would have little change in the time between the peak spawning runs, egg development, and larval emergence. In extremely dry years (the lowest 1 percent), the freshet would begin a couple of days earlier, but would be sustained longer. During the driest 10 percent of years, the discharge duration would be sustained about 8 percent to 9 percent higher in May and June, which could increase larval dispersal downstream in very low water years.

Spring flows for juvenile outmigration would be a negligible change from the No Action Alternative in March and April, and a 10 percent increase in May in the driest 1 percent of years that would be a minor benefit to juvenile outmigration in those years. Higher flows are linked to higher predation rates on adults, but the minor increase in flows in extreme dry years would likely be a negligible effect on adult predation in those driest years.

***Green Sturgeon***

<u>Summary of Key Effects</u>

The Columbia River use by green sturgeon is primarily foraging habitat for adults and subadults. Key effects of MO4 would be similar to the No Action Alternative in most years. Hydrology modeling indicated in dry years (lowest 25 percent of years) there may be a variation between the months of July when flows would be 4 percent higher than the No Action Alternative and August when flows would be 5 percent lower than the No Action Alternative. This change of flows (when flow augmentation would cease) could cause forage sources to move further upstream in July and then downstream in August, but sturgeon would likely be able to continue foraging effectively and this would be a negligible effect.

***Pacific Lamprey***

<u>Summary of Key Effects</u>

MO4 has several measures that are designed specifically to benefit lamprey. These measures are proposed structural improvements that would include converting extended-length submersible bar screens to submersible bar screens, expanding the network of Lamprey Passage Structures to bypass impediments in fish ladders, changing the design for turbine cooling water strainers, replacing turbines for safer fish passage, among other physical modifications to reduce fish injury and mortality.

The most substantial benefit of MO4 would be the improvements to get fish to enter the fish ladders; this would occur through expanding the network of Lamprey Passage Structures and modifying fish ladders to incorporate lamprey passage criteria into the structural modifications. Adults migrating upstream in July would experience higher water temperatures in the Columbia River from Chief Joseph Dam to McNary Dam that would likely lower their survival and migration success.

<u>Larval Development/Juvenile Rearing</u>

Hydrosystem operations affect larval lamprey rearing in shallow waters due to elevation fluctuations that can dewater larvae rearing in sediment. Rates that lower the water level less than 10 cm per hour are natural, but faster than that can strand lamprey. In MO4, drawdowns in late March could dewater larval lamprey rearing in sediment. Most fine sediments at tributary junctions host lamprey. This alternative could reduce the amount of habitat available for larval lamprey (reference to be added prior to final). Although it is difficult to quantify, the effect is anticipated to be minor to moderate.

As juveniles are rearing, temperature affects outmigration: juveniles move out of the system faster in warmer temperatures. This alternative would have no change in the Snake and Lower Columbia Rivers, but the middle Columbia reach would have minor increases in July during low flow years. It has not been quantified what influence this may have on number of lamprey or intensity of effect. If juveniles are triggered to migrate earlier compared to the No Action Alternative, they would likely be slightly smaller and therefore slightly less fit for the long journey down river.

<u>Juvenile Fish Migration/Survival</u>

A substantial amount of injuries and mortality can occur for outmigrating juveniles on their downstream migration including impingement on screens.

These measures are also in MO1 and their effects are described in more detail in the lamprey section in that alternative. Briefly, the measures and their anticipated effects would be:

Converting the extended-length submersible bar screens to submerged traveling screens would substantially reduce mortality due to impingement.

- A new design of structure for exclusion of juvenile lamprey from cooling water strainer intakes would substantially reduce or eliminate this pathway of mortality.
- Additional powerhouse surface passage would change the dynamics of lamprey passage. A higher percentage of lamprey would be expected to pass via the safer surface routes instead of the turbines in relation to the No Action Alternative.
- Replacing turbines at John Day Project with a newer design of turbine would improve conditions for fish passage and reduce the injury rate for lamprey.
- The hydraulic analysis shows an increased hydrograph in May/June in low water years, which could benefit lamprey from upper river areas as it could increase outmigration triggers and speed.
- Reservoir drawdown to MOP to speed up outmigration travel time would benefit juvenile outmigrating lamprey.
- American lamprey lack a swim bladder and are considered less susceptible to barotrauma than salmonids (Colotelo et al. 2012).

Because of the high degree of uncertainty surrounding how many juvenile lamprey are lost or injured on their downstream migration, it is difficult to quantify the improvement represented by all of the measures. For fish that encounter multiple dams on their migration downstream, reducing the total number of hazards would increase their probability for survival to adult life stage.

Adult Migration/Survival

Similarly, there are measures in MO4 that were also in MO1 that improve adult lamprey passage; they are described and analyzed in detail in the lamprey section of MO1 and summarized here:

- Expanding the network of lamprey passage structures would improve lamprey passage.
- Modifying the upper ladder serpentine flow control ladder sections at Bonneville Dam would reduce migration delays caused by baffles in this section.
- Adding cooler water in the fish ladders at Lower Monumental and Ice Harbor would be expected to benefit lamprey because this has been successful at Little Goose and Ice Harbor.
- Modifications to Lower Monumental include diffuser grate plating. This modification has been completed at all other ladders in the CRS, except Lower Monumental, and has resulted in slight benefits to lamprey passage.
- Johnson et al. (2012) found that lamprey passage is inhibited when ladder velocities are too high and when attraction flow to a lamprey entrance is hard to distinguish from nearby discharges such as spillway or turbines.

The overall expected improvements in lamprey passage efficiency should decrease susceptibility to physical stress and mortality, and shorter holding time would be beneficial to the fish. These structural measures for lamprey are expected to provide a substantial benefit to the population size and distribution of Pacific lamprey in the Columbia Basin. Compared to the No Action Alternative, all proposed structural measures to reduce losses would have benefits to the population and recruitment to the next generation. The combined effect of all proposed structural modifications would be a substantial improvement for lamprey survival and fitness.

A site- and timing-specific analysis of water temperatures indicates slightly warmer conditions in July of low water years, when temperatures would be most stressful. At McNary Dam, outflow temperature would exceed 20°C in 57 days of low flow, high temperature year types (similar to 2015), compared to 22 days in the No Action Alternative. This would result in lower migration success and survival of adult lamprey.

***American Shad***

<u>Summary of Key Effects</u>

No change is anticipated to plankton communities, but shoreline habitat is expected to decrease under MO4, so there may be a minor decrease in juvenile shad. The proportion of shad moving upstream of McNary Dam in low flow years may increase under MO4, so an overall decrease in shad abundance is anticipated relative to the No Action Alternative but the magnitude of that change is uncertain.

<u>Juvenile Fish Migration/Survival</u>

Plankton communities and shoreline habitat are not expected to change in the lower Columbia reservoirs relative to the No Action Alternative, so no changes are anticipated for juvenile shad. Shoreline habitat would decrease due to the lower Columbia River drawdowns to near minimum operating pool elevations, but the lower Snake River shoreline habitat area is not anticipated to change.

<u>Adult Fish Migration/Survival</u>

In low flow years under MO4, the proportion of adult shad counted at Bonneville Dam that migrate upstream past McNary Dam may increase due to concomitant minor increases in summer water temperatures in the John Day pool in this alternative, relative to the No Action Alternative. However, the average monthly flows for in MO4 would be higher than the No Action Alternative in some months (for example, July), and lower in other months, so overall the proportion of adult shad passing McNary Dam would likely be mixed or no effect due to this variability in temperatures and flows.

## RESIDENT FISH

### Region A

#### *Kootenai River Basin*

<u>Summary of Key Effects</u>

Key effects to resident fish resources under MO4 would include decreases in reservoir productivity in wet years and a delay in summer productivity in the Kootenai River below Libby Dam. Conversely, MO4 would have a greater potential for cottonwood establishment and riparian regeneration, but flows would provide the least usable habitat for bull trout, redband rainbow trout, and westslope cutthroat trout of all the MOs.

<u>Habitat Effects Common to This Fish Community</u>

MO4 would have a lower rate of flow increase from Libby Dam between mid-March and mid-May than the No Action Alternative. Under MO4, the rate of flow increase would be less than the No Action Alternative. This decrease in flow rate under MO4 would also result in a greater delay in commencement of river productivity than under the No Action Alternative.

MO4 would increase the potential for cottonwood and willow seeding and recruitment compared to the No Action Alternative. Under MO4, there would be nearly three times the number of days when the winter peak stage would not exceed 1753 feet at Bonners Ferry, which is a generic surrogate for the previous year's seeding peak stage. There would also be a greater difference river elevation between the winter and spring peak stage at Bonners Ferry when compared to the No Action Alternative. MO4 would have the greatest potential of all the MOs for riparian regeneration. However, steadily increasing median flows in late summer would adversely impact varial zone productivity (i.e. inundation of previously non-wetted river margins and shifting photic zone would reduce productivity potential), but these effects could possibly be mitigated with real-time operation considerations. MO4 would have a lower rate of recession of river stage at Bonners Ferry during the seeding seasons than the No Action Alternative. This lower recession rate of MO4 would better promote cottonwood establishment than the rate under the No Action Alternative.

<u>Bull Trout</u>

Effects of MO4 to bull trout that differ from the No Action Alternative include large reductions in reservoir productivity, lower minimum and maximum water levels at Lake Koocanusa, large decreases in reservoir elevations at Libby Dam, and decreases in usable habitat for juvenile and adult bull trout.

Under MO4, Lake Koocanusa would above elevation 2,450 feet for 33 days during the summer productivity period (June 15-September 15) compared to 44 days under the No Action Alternative. In dry years there would be no days with lake elevations above 2,450 feet. This would lead to reductions in maximum surface productivity potential in all but the wettest years, and especially in dry years. Primary and secondary food production would be reduced, which would likely adversely affect bull trout growth and/or survival.

The median minimum and maximum elevation of Lake Koocanusa under MO4 would be the same as No Action Alternative, though drier years as measured at The Dalles would result in further decreased minimum elevations than No Action Alternative. The expected result would be more frequent annual dewatering and decreased benthic insect production, which may result in a decrease in bull trout growth and/or survival.

Under MO4, the higher pool elevations during the winter associated with flood risk management and power generation could result in a colder thermal mass that warms slower in early spring. The subsequent cooler releases would delay in-reservoir and downstream productivity. This would lead to slight reductions in resident fish growth and survival. However, reservoir elevations by late April would be lower than the No Action Alternative and this would increase warming.

Under MO4, Libby Dam discharge at peak flows would be lower than under the No Action Alternative. These flows provide less ability than the No Action Alternative to mobilize or reshape tributary deltas that can prevent bull trout access during the fall (low river flow).

MO4 would have many more days of increasing flows than the No Action Alternative. Under MO4, the median Libby Dam discharge would drop precipitously at the end of August, desiccating benthic productivity between the late-August maximum discharge and the minimum bull trout flow of 6 kcfs. In addition, MO4 is expected to have a substantially larger adverse effect on the productivity of the varial zone of the Kootenai River downstream of Libby Dam due to steadily increasing discharge through August in years when the McNary flow augmentation measure is triggered, which would likely reduce growth and/or survival of juvenile bull trout through an adverse impact on the food web and on fish bioenergetics and metabolism. These effects could potentially be mitigated with real-time operation considerations.

MO4 would have higher discharges than the No Action Alternative, but would provide less weighted usable habitat for juvenile (day and night) and adult bull trout than the No Action Alternative. MO4 would provide the least usable habitat for juvenile (day and night) and adult bull trout for all of the MOs. Given these results, lower usable habitat may result in reduced growth and/or survival of all life stages of bull trout under this alternative.

Kootenai River White Sturgeon

MO4 would provide 11 day less than 20 kcfs discharge compared to the No Action Alternative. This would likely result in a negligible reduction in the number of spawning adult Kootenai River white sturgeon that migrate to spawning habitat upstream of Bonners Ferry.

In addition, MO4 would draft Lake Koocanusa to a lower pool elevation than the No Action Alternative for Dry and Average forecasted years. This would allow the lake to warm slightly faster. This faster warming would initiate earlier onset of spring warming in the river below the dam (via selective withdrawal) and increase summer productivity and fish growth slightly.

<u>Other Fish</u>

While the minimum and maximum elevations at Lake Koocanusa for MO4 would not differ from the No Action Alternative, on average water levels would be lower for the summer growing season. This would result in slightly less insect larvae production and less food available for resident fish species. However, on wet years MO4 would maintain higher pool elevations through the winter and spring than the No Action Alternative. This operation may be more beneficial to benthic insect production during these years.

MO4 would have slightly higher discharges from Libby Dam for the period May 15 to September 30 than the No Action Alternative, but would provide less weighted usable habitat for juvenile and adult redband rainbow trout than the No Action Alternative. Lower usable weighted habitat may result in reduced growth and/or survival of all life stages of rainbow/redband trout. We assumed that these effects would be similar for westslope cutthroat trout.

Mean flows under MO4 as measured at Bonners Ferry between January 1 and April 30 would be slightly higher than the No Action Alternative. These flows would be slightly less likely than the No Action Alternative to provide the low flows needed for successful burbot recruitment.

***Hungry Horse/Flathead/Clark Fork Fish Communities***

<u>Summary of Key Effects</u>

The key effects of MO4 are largely biological responses to changes in Hungry Horse Reservoir elevations and outflows to provide additional water supply and flow augmentation in dry years. Lower elevations through the summer would decrease food supply for fish with minor reductions in plankton production and surface area for summer terrestrial insects in wet and average years and moderate effects in dry years. Benthic insect production important to fish would be appreciably decreased under MO4. Lower surface elevations could also increase issues with predation/exploitation risk as fish migrate into and out of tributaries to fulfill their life cycles, and increased outflows in summer would likely result in increased entrainment of zooplankton and fish out of Hungry Horse Reservoir. Increased flows in the South Fork Flathead River would be attenuated with flows from the mainstem Flathead River but would still result in higher summer flows that would decrease native fish habitat suitability in that reach. MO4 would have negligible effects on Flathead Lake, lower Flathead River, or Clark Fork fish.

<u>Habitat Effects Common to This Fish Community</u>

Wet and average year types under MO4 would be similar to MO1 effects. In dry years, however, the reservoir would be drafted much deeper with higher outflows in the summer months. Modeling shows in wet and average water years the reservoir would still reach near full pool (elevation 3,560 feet) by early July in most average years and mid-July in wet years. However, in these year types the median elevation at the end of September would be 3,546 feet, or about 4 to 5 feet lower than the No Action Alternative. In dry years the reservoir would still approach full pool, miss filling and typically become drawn down much faster in the same pattern as the No Action Alternative, but the dry year elevation would be a median of 10 feet lower than the No Action Alternative dry year. All year types considered, there would be a 60 percent probability of reaching elevation 3,559 feet by July 31, or 15 years more out of 100 that would not reach full compared to the No Action Alternative. In fall and winter months, MO4 would be lower than the No Action Alternative, following the same pattern as MO1 and MO3, but deeper in some years.

Lake elevation in the warm summer months determines the volume of reservoir that would be available to produce plankton (euphotic zone). With lower summer elevations, the euphotic zone would decrease under MO4 in all year types, with the effect being most extreme in dry years. In early June, MO4 and the No Action Alternative are similar in wet and average years, but by July, they begin to diverge with MO4 becoming less than the No Action Alternative. By September, the euphotic zone would be from 32,000 to 37,000 acre-feet smaller than the No Action Alternative in wet and average years, representing a decrease of about 2 percent to 3 percent. In dry years, the median MO4 volume would be about 89,500 af smaller than the No Action Alternative or decreased by about 7 percent. In extreme years, the elevation in dry years would be as much as 16 feet lower elevation at the end of September under MO4, which would reduce euphotic zone by about 158,000 af, or 13 percent compared to the No Action Alternative. Drawdowns any time during the year affect the production of insects that live on the bottom of the reservoir. As reservoir elevations drop, insects that have established in this zone can become dewatered. The insect eggs would have been deposited within the euphotic zone described above. If reservoir levels drop, that zone remains the same thickness and drops with the surface level, but there would be no insects deposited at the lower elevation that would become the euphotic zone. As the elevation drops, the surface for benthic insect production gets smaller. MO4 drops faster than the No Action Alternative in the summer and would be at a median of six to nine feet lower elevation through the following fall and winter. This would result in less area for benthic insect production than the No Action Alternative. In dry years there would be more severe losses, especially with more than one dry year in a row as the reservoir would go into the following water year lower and then be drawn down even further. Some of the larger aquatic insects have long life cycles that require overwintering where they were deposited; lower winter elevations would reduce the survival of these important insects. Using surface area as an index for benthic area, MO4 surface area would decrease in most months of all year types, with the exception of spring/early summer in wet years. Where decreases would be expected, they would range from about 100-over 1,000 acres compared to the No Action Alternative, or about 1 percent to 5 percent. In dry years, the summer months would have surface area 4 percent to 5 percent lower than the No Action Alternative, or a difference of about 730 to 1,030 acres. The large bays at the upper end of the reservoir could experience a proportionally higher rate of dewatering with dropping levels over the summer due to more shallow slopes where an equal drop in elevation would result in a larger dewatered benthic surface area and a considerable loss of aquatic macroinvertebrates that had been established due to desiccation.

Finally, the reservoir elevation determines the surface area available for terrestrial insects to land on the water and be available for fish food, as well as influencing the proximity of the water's edge to terrestrial vegetation and therefor the ability of the two non-flying orders of important insects to be available to fish by passively landing in the water. Under MO4 operations, there would be about 100 to 400 acres (1 percent to 2 percent) less surface area for summer feeding in wet and average year types and 900 to 1000 acres (4 percent to 5 percent) less in dry years.

Zooplankton would continue to be entrained into the South Fork Flathead River from Hungry Horse reservoir. The zooplankton enhances food supply in the South Fork Flathead River and along the near bank of the Flathead River but decreases food supply for fish in Hungry Horse Reservoir. Outflows, and therefore zooplankton entrainment, under MO4 would be at least 8 to 17 percent higher in July and 35 to 37 percent higher in August and September, and 11111 to 12 percent lower in fall through spring. These zooplankton are concentrated in the withdrawal zone in summer so the entrainment effect from increased summer outflows would be disproportionately high.

Outflow patterns from Hungry Horse Reservoir can also affect how fish are entrained into the South Fork Flathead River, and the habitat conditions, such as river elevation (stage), velocities, and temperatures in the river. These effects continue downstream to affect the main Flathead River in the same patterns, but somewhat attenuated by the flows in the mainstem Flathead. Temperatures in summer are regulated with a selective withdrawal structure that is operated to release water of a temperature that favors native fish. A further departure from normative flows due to higher flows would further reduce habitat for native fish in the South Fork Flathead River. Insect production in this reach would also be affected. As modeled, the steep dip in the hydrograph in mid-June of dry years would functionally reset the life cycle of aquatic macroinvertebrates. It would take until August for the biota to recover to become a food source for fish, and by that time, the time period for fish growth would be almost over. This would result in lower growth rates for fish in the South Fork Flathead River.

The temperature control structure would still operate in the summer months as in the No Action Alternative so changes in outflows in this timeframe would not affect summer temperatures downstream.

In the Flathead River down to Flathead Lake, habitat suitability is a key issue in the No Action Alternative due to unnaturally high flows in the summer and winter. Under MO4, mid-July through September flows would be 14 to 22 percent higher than the No Action Alternative summer flows, and winter flows in MO4 would be slightly lower than the No Action Alternative. Spring peaks would also be slightly lower than the No Action Alternative. Winter flows would continue to limit establishment of riparian vegetation important to fish, and spring peaks only slightly lower than the No Action Alternative would continue to occasionally provide flushing of sediments from gravels to maintain habitat.

The winter water temperature warming influence from the contribution of the South Fork Flathead would be slightly less due to slightly lower winter flows out of Hungry Horse. TDG in the Flathead River would be similar to the No Action Alternative, continuing to fluctuate with spill at Hungry Horse dam but, generally speaking, would not exceed 117 percent, which is within a safe zone for fish.

The influence of MO4 changes to Flathead Lake levels would be minimal. Seli'š Ksanka Qlispe' Dam outflows would increase 5 to 12 percent in August and 6 to 7 percent in September and decrease 2 to 5 percent in April through May. Flows would be similar to the No Action Alternative in winter.

Bull Trout

MO4 conditions would be similar to MO1 in wet and average years, with reduced summer production of zooplankton that fuels the food web and surface area available for summer terrestrial insect feeding. In dry years, there would be further reductions to zooplankton. The lower reservoir elevations would result in substantially lower surface area for benthic insect production throughout the year, as well as desiccation of the portion of these insects that have established at elevations that become dewatered. This effect is especially in the bays at the upper ends of the reservoir lobes. Juvenile bull trout moving into the reservoir in the spring rely on the benthic insects in these areas until they transition to eating fish. The prey items that adult bull trout eat also consume these benthic insects and may be in poorer condition or less plentiful in areas. This could result in bull trout being in poorer condition.

Reservoir elevations influence the access to spawning tributaries and the degree of varial zone effects such as predation risk and exposure to angling exploitation that fish experience. Bull trout spawn in the fall. Lower reservoir elevations in the fall as described in the physical habitat section would increase the risk and exposure for upstream migrating bull trout. The sedimentation of tributary deltas currently is not known, but there could potentially be blockages of passage arise with lower elevations as well. These effects would likely be moderate in wet and average years with 3 to 4 feet difference from the No Action Alternative, but dry years could see much lower elevations (up to 16 feet) and more extreme effects in years when the elevations would already be causing access and varial zone issues under the No Action Alternative.

Bull trout entrainment through the dam would increase in MO4 due to increased outflows in late summer. In MO4 these outflows would be 35 to 37 percent higher than the No Action Alternative, and entrainment of bull trout would be expected to increase at least that much. Withdrawals in August and September are generally selected from deep in the water column to release the target temperature, and bull trout have been documented in this stratum at this time of year. The relationship between outflows and entrainment would likely be higher than a direct correlation because of increased risk for bull trout at this time of year. Entrainment rates of bull trout under the No Action Alternative are not known, but a considerable increase expected due to MO4 could rise to population level effects.

The number of individual bull trout in the South Fork Flathead River below Hungry Horse Reservoir may increase with greater entrainment, but these would be lost from their spawning populations. Zooplankton available in the South Fork Flathead River may increase in summer with higher outflows. As in the reservoir, food web relationships are important. The MO4 Alternative would continue to allow for this transitory use by bull trout and other native fish with adequate food. Higher flows may also increase benthic production of food for bull trout prey fish, but increased velocities would result in lower availability of suitable habitat for bull trout due to higher velocities.

Summer flows in the mainstem Flathead River would be higher than the No Action Alternative, further decreasing habitat suitability. Muhlfield et al. (2011) found even moderate increases in flows resulted in substantial decreases in suitable area for bull trout due to velocities, and that nighttime habitat for subadult bull trout was most sensitive. For each increase of 1,765 cfs in Flathead River flows, a decrease of 11 percent habitat would be expected. The median summer flows at Columbia Falls increase under MO4, which is expected to decrease the nighttime habitat for bull trout in this reach of river by about 6 percent. The mainstem Flathead River would be similar to the No Action Alternative in winter and spring, with barely perceptible changes from the No Action Alternative.

Operations of Seli'š Ksanka Qlispe' Dam (Flathead Lake) would also result in increased outflows (6 to 12 percent higher than the No Action Alternative in the late summer months. Entrainment of bull trout would not be an issue because they would not be found near the outlets at that time of year due to warm temperatures.

<u>Other Fish</u>

Hungry Horse Reservoir favors a native fish dominated fish community. Juvenile bull trout and adult whitefish, northern pikeminnow, sculpins, and westslope cutthroat trout feed on zooplankton, aquatic insects, and terrestrial insects, and adult bull trout prey on mountain whitefish, suckers, minnows, etc. The food web effects described above would also apply to all of these species of fish in Hungry Horse Reservoir. Decreases in zooplankton and reduced summertime feeding of terrestrial insects could reduce food supply in summer. Substantial decreases in aquatic macroinvertebrate due to dewatering events and reduced surface area for production would decrease the food supply for many of these fish.

Westslope cutthroat trout and other native fish spawn in the spring (April through June), so effects on adults migrating into tributaries to spawn would differ from bull trout. Spring spawning fish migrate when reservoir levels are lower and tend to experience longer varial zones with increased predation exposure. Under MO4 operations, the median modeled April and May elevations would be five and three feet lower, respectively, than the No Action Alternative. In dry years, the median elevation would remain lower than the No Action Alternative the entire summer. Spring spawning fish such as westslope cutthroat trout would experience greater considerably greater varial zone effects on their way upstream as adults, and could encounter some tributary blockages, but the delta formation of these tributaries is not known. Juveniles typically outmigrate in June. In dry years, especially, juveniles would experience higher predation risk as they outmigrate from the tributaries, through the varial zone without suitable cover, and into the reservoir.

Entrainment from the reservoir of all fish species is known to occur but not quantified. Entrainment would increase under MO4, especially in late summer months with outflows up to 37 percent higher than the No Action Alternative. All fish would experience increased entrainment, but northern pikeminnow and bull trout have been documented at the depths of late summer withdrawal and would be most susceptible to entrainment at rates greater than a direct correlation.

Habitat suitability described for bull trout would be similar for other native fish (Muhlfield et al. 2011) in the South Fork Flathead River and mainstem Flathead River, with higher summer flows in MO4 resulting in appreciably decreased amount of suitable habitat available in summer when flows are higher than the No Action Alternative.

Effects to fish in Flathead Lake would be similar to conditions described in the No Action Alternative. The lower Flathead River would experience increased outflows in summer that would 7 to 12 percent higher than the No Action Alternative. This would further change conditions described in the No Action Alternative flows that tend to favor non-native fish in the lower Flathead River and Clark Fork Rivers.

#### ***Lake Pend Oreille (Albeni Falls Reservoir)/Pend Oreille River***

<u>Summary of Key Effects</u>

Key effects to fish and aquatic resources under MO4 include lower summer pool elevations on dry years that may limit access to tributary habitats and reduce the quantity of important shallow water habitats.

<u>Habitat Effects Common to All Fish</u>

On dry years under MO4 Lake Pend Oreille pool elevations may be as much as 2.5 feet lower June through September compared to the No Action Alternative. This water level may limit access to tributary habitats and would represent a reduction in shallow water weedy habitats in tributary inlets that support warm water fish species.

<u>Bull Trout</u>

Effects to bull trout from MO4 include water level manipulations on drier years. Compared to the No Action Alternative water levels on dry years may be up to 2.5 feet lower under this alternative. On these drier years, access to tributary habitats during summer months may be more limited under MO4 than the No Action Alternative.

<u>Other Fish</u>

On dry years under MO4, Lake Pend Oreille pool elevations may be as much as 2.5 feet lower June through September compared to the No Action Alternative. Under these conditions, there would be a decrease in suitable habitat for warm water fish using weedy shoreline habitats near inlets. Specifically, northern pike, largemouth bass, and smallmouth bass would experience some decrease in summer habitat.

**Region B**

***Lake Roosevelt/Columbia River from U.S.-Canada Border to Chief Joseph Dam***

<u>Summary of Key Effects</u>

Flow, elevations, and water quality affect the quality of habitat for various resident fish species above, in, and downstream of Lake Roosevelt. The Columbia River from the U.S.-Canada border would continue to support a white sturgeon population that spawns successfully but primarily relies on fish manager intervention to survive a recruitment bottleneck; conditions for natural recruitment may be further diminished in a small proportion of years. In Lake Roosevelt, there would be major effects to fish. Retention time is a key metric for most fish species in Lake Roosevelt, driving the food web that supports the fish as well as influencing how many are entrained. It would be considerably lower in late spring and summer in dry years resulting in increased entrainment and decreased food supply. Lower retention times in winter would also increase entrainment risk compared to the No Action Alternative. Lake elevations under MO4 would increase risk of impeded tributary habitat access and egg drying out or stranding for redband rainbow trout, especially in dry years where effects would be major and failure of year classes of some rainbow trout is likely. The portion of kokanee that spawn in tributaries would continue to have access in fall similar to the No Action Alternative in wet and average years but experience higher magnitude of varial zone effects. Reservoir operations would result in increased egg drying out of the burbot spawn and the portion of kokanee that spawn on lake shorelines compared to the No Action Alternative. MO4 would have substantial adverse impacts to native fish species, dependent on the water year. Failures of entire year classes are expected while habitat conditions are expected to improve for predatory non-native warmwater species, further expanding their range. Hatchery raised net-pen fish would be subjected to poorer water quality upon release and would likely be entrained at much higher rates and lost from the Lake Roosevelt populations. Northern pike would likely continue to increase and invade downstream, and the lake elevations could decrease the ability for boat suppression efforts. Entrainment of northern pike juveniles would likely increase and hasten the rate of invasion downstream. Reservoir fluctuation events could increase contaminant uptake by fish as this variability activates mercury into the water. Rufus Woods Lake would continue to provide habitat for fish entrained from Lake Roosevelt and from limited production of shoreline spawning by some species; entrainment could increase in spring and summer months. TDG would be similar or less than the No Action Alternative.

<u>Habitat Effects Common to This Fish Community</u>

The summary hydrograph of Lake Roosevelt water elevations influences many of the fish species in Lake Roosevelt. Refer to Chapter 3.2 for a full description of the changes in reservoir elevations. Operations would have targets to meet the metric of reaching a lake elevation of 1,283 feet by the end of September, which would be met in average and wet years, but the median dry year elevation would be seven feet lower. The winter draft in MO4 would start December 1 compared to February in the No Action Alternative, and reservoir levels run about 7 feet lower through these early winter months, with elevation variations shown in the modeling that would be smoother in real operations. In average and wet years, the spring and summer would be similar to MO1. Initiation of refill would be about May 1 where the levels would rise until reaching a target full pool of about 1,289 feet by early July. In dry years, however, is where MO4 differs substantially from the No Action Alternative and the MOs. The median dry year values have the reservoir failing to refill. In the beginning of May, it still would be drafting to support the McNary Dam Flow Augmentation, and it would not start to refill until June. Peak refill would be more than 20' lower the No Action Alternative as the pool would begin to draft again in July and August for augmentation flows. Median peak outflows follow the same pattern as the No Action Alternative with peaks in early June and another, smaller peak in July. The MO4 flows in early spring through August in wet and average years would be about 2 percent to 5 percent lower than the No Action Alternative. In dry years, however, outflows in May and June would increase by 5 percent to 12 percent, and then would drop to about 3 percent to 15 percent lower than the No Action Alternative flows in August, September, and October. December and January flows would be slightly (-1 percent to 4 percent) higher than the No Action Alternative. These peak outflows can influence the rate of entrainment from Lake Roosevelt into Rufus Woods Lake. TDG in the Grand Coulee tailwater is also a concern for fish in Rufus Woods Lake. Under the MO4 TDG would be lower than the No Action Alternative.

Retention time of water through the reservoir is a driving metric for the food web in Lake Roosevelt and influences the populations of several fish species. In MO4, retention time in December through May is related to winter FRM, Planned Draft Rate, and Upstream Storage Correction.

Generally speaking, under MO4 median retention time would be considerably lower than the No Action Alternative during critical time periods for a number of fish relationships. In dry years, retention time would be much lower in May to August (29 percent, 28 percent, 21 percent, and 11 percent medians in May, June, July, and August, respectively). These reductions of up to 9 days retention time could greatly affect food webs and entrainment of zooplankton and fish in the reservoir. It would be moderately higher in September and October and moderately lower in winter. In average years, retention time under MO4 would be 3 percent to 9 percent lower than the No Action Alternative in the critical spring/summer months, and moderately higher in fall and moderately lower in winter. In wet years, the summer months would be similar or slightly less than the No Action Alternative, higher in October, and moderately lower through the winter. In wet years is when retention time is lowest because more water is moving through the system, and MO4 would reduce retention times even further in these years by up to 9 percent in February and by 3 percent to 9 percent in the entire period of December through May.

Kokanee, redband rainbow trout, juvenile burbot, larval sturgeon, and many prey species rely directly on the food source provided by the zooplankton production and higher-level predators such as bull trout prey on these fish. Zooplankton are more widespread, more plentiful, and larger body size when retention times are higher, and tend to be smaller bodied, swept out of the reservoir faster, and more concentrated near Grand Coulee dam with lower retention time. With lower retention times under MO4 in winter and spring, when retention times are already fairly low, there would be less food available to fish, and they would also tend to follow the food source and crowd down towards the dam, becoming more susceptible to entrainment. The large magnitude of lower retention times in summer months of dry years would be expected to increase entrainment of kokanee, redband rainbow trout, and other native fish as well as increase the invasion of non-native fish such as northern pike downstream.

<u>Bull Trout</u>

Bull trout are temperature sensitive and would continue to use this reach for foraging, migration, and overwintering habitat until temperatures reach stressful levels, which would be the same as the No Action Alternative. Bull trout in Lake Roosevelt could continue to move to cooler locations in the reservoir and these refuges would remain similar to the No Action Alternative. High flow years would continue to influence bull trout distribution through flushing more of them from the river near the U.S.-Canada border down into Lake Roosevelt. Peak flows at the U.S.-Canada border were modeled showing a decrease of about 1 percent to 2 percent under MO4, which would likely be a negligible change to bull trout distribution similar to MO1, MO2, and MO3. Increased outflows in January through May could potentially increase entrainment of bull trout, but this would be negligible because of the scarcity of bull trout in Lake Roosevelt. Bull trout prey base would continue to fluctuate, as the fish they eat are sensitive to changes in productivity and location of zooplankton in Lake Roosevelt that is influenced by the retention time of water in the reservoir, which would be adversely affected by lower retention times in MO4. In dry years, the decrease in retention time in spring and summer would tend to flush zooplankton more quickly and concentrate prey fish that bull trout eat closer to the dam, where they would be more susceptible to entrainment, especially in May when outflows would be 5 percent to 12 percent higher than the No Action Alternative. Bull trout are also sensitive to contaminants that are found in this region and would continue to bioaccumulate contaminants as a top predator. Bigger fluctuations in reservoir levels under MO4 that would increase the exposure of shorelines and the increased fluctuation events could increase methylmercury production, a highly toxic organomercury compound which bioaccumulates in fish (Willacker 2016).

<u>Other Fish</u>

In the Columbia River reach from the U.S.-Canada border to Lake Roosevelt, white sturgeon are typically able to spawn as evidenced by capture of young of the year larvae (Howell and McLellan 2018), but rarely experience successful recruitment from larvae to juvenile sturgeon, and only in extremely high water years. Successful recruitment appears to be dependent on a combination of flows exceeding 200 kcfs and water temperatures of about 14°C for 3 to 4 weeks in late June/early July (Howell and McLellan 2005 Howell and McLellan 2011 and Howell and McLellan 2014). Under MO4, flow over 200 kcfs in June and July would have a slight decrease These slightly reduced flows at the U.S.-Canada border would result in a minor decrease in the recruitment window. The timing of these flows coinciding with lower reservoir levels can also increase recruitment ability with the longer riverine habitat provided by a lower reservoir. MO4 reservoir levels would be similar to MO1 in wet and average years, with slightly lower elevations. In dry years, the reservoir would be considerably lower and provide more riverine habitat length, but flows would not have been high enough for sturgeon to successfully spawn. Other factors that would continue to influence sturgeon include predation by fish that are favored by reservoir conditions if larvae are flushed into the Lake Roosevelt. Slightly lower flows in spring could slightly reduce the risk of larvae entering Lake Roosevelt. The uptake of contaminants such as copper closer to the U.S.-Canada border being flushed downstream into the reservoir by high flows would also be slightly lower. Under MO4, recruitment of white sturgeon would continue to be a rare event supplemented by hatchery propagation, as larval sturgeon are captured and raised in hatcheries until they are past the window where recruitment has been shown to fail at a high rate. Once these juveniles are released back into the reservoir they continue to grow and survive well. The reservoir would continue to provide good conditions for growth and survival of these fish. In dry years there would be more riverine habitat and less lake-like habitat, which could tend to favor white sturgeon juveniles over non-native species.

Wild production of native fish such as burbot, kokanee, and redband rainbow trout would be impaired for populations in Lake Roosevelt. As described in the common habitat effects, these fish are the most sensitive to the effects of changing retention times. Under the No Action Alternative an estimated average of over 400,000 fish annually would be entrained, with 30 to 50 percent of them being kokanee, primarily of wild origin and rainbow trout the second most entrained species. Under MO4 operations, greatly increased entrainment would be expected in spring and summer months of dry years as the outflows increase over the No Action Alternative and retention times are up to 9 days or 30 percent faster. Summer months were found to be the months with the highest rates of entrainment, and in years of high entrainment May, June, and July losses were estimated in the range of about 90,000 to up to 200,000 fish per month (LeCaire 2000) under the No Action Alternative. Increases of 30 percent in these months would likely decrease populations of kokanee and rainbow trout. Wild kokanee would likely be the majority of fish entrained. Entrainment would also be expected to increase in winter in all year types, and December through May in wet years.

The decreased retention time in spring and summer of average and dry years, especially, would also likely adversely affect food sources for fish in Lake Roosevelt to the point of affecting growth of kokanee and other fish. Increased entrainment of zooplankton in winter would decrease food availability that is key to winter survival and growth of several fish species including kokanee, juvenile burbot, and other juvenile fish, though this effect would be somewhat mitigated with increased retention times in September and October that would flush fewer of these zooplankton out in the fall than under the No Action Alternative.

For tributary spawning species such as redband rainbow trout and a portion of the wild production of kokanee, tributary access at the right time of year is important. Reservoir drawdown in the spring creates barren tributary reaches through the varial zone, which directly and indirectly impedes migration to and from tributaries and the reservoir. The operational metric of reaching a lake elevation of 1,283 feet by the end of September would be met under MO4 in average and wet years, but would be about median dry years would be 7 feet lower and levels would be lower than the No Action Alternative in October through December as well.

Lower elevations could impede access and increase predation risk and increase volitional migration time for kokanee. Redband rainbow trout need access tributaries in the spring. Under MO4, reservoir elevations would be slightly lower than the No Action Alternative levels in the critical spawning migration time of April and May in wet and average years, and considerably lower in dry years. This would be most extreme in dry years, with large deviations from the No Action Alternative levels, but also most critical in wet years (20 percent of years) when the median elevation would be 1,217 ft at the lowest point in early May, 5 feet lower than the No Action Alternative. Migratory impacts although not well documented, could be severe for Redband rainbow trout given the timing and extent of drawdowns in MO4. Specific tributaries of concern that redband rainbow trout spawn in Sanpoil, Blue Creek, Alder, Hall Creek, Nez Perce Creek, Onion Creek, Big Sheep Creek, and Deep Creek. These tributaries higher in the basin are more susceptible to elevation changes because a smaller change in lake elevation would result in a larger area of exposure than tributaries closer to the dam. Additionally, increased exposure during migrations to these tributaries would increase the varial zone effect where migrating fish are more exposed to predation and angling due to lack of cover.

Species such as kokanee and burbot that spawn on shorelines in Lake Roosevelt are susceptible to egg desiccation if reservoir levels drop while eggs are still in the gravel. Kokanee spawn on shoreline gravels September 15 to October 15 and eggs incubate through February. Burbot tend to spawn successfully in depths provided by MO4 in the Columbia River and in Lake Roosevelt on shorelines near the Colville River in winter with eggs incubating through the end of March (Bonar et al. 2000). MO4, compared to the No Action Alternative, begins dropping 2 months sooner and would likely strand or dewater burbot and kokanee eggs more than the No Action Alternative. A higher proportion of eggs at all elevations would be affected in all year types due to fluctuations in the modeled elevations, although these could be smoothed out somewhat in real-time operations. MO4 dry year scenarios would strand and desiccate considerably more eggs and larvae than the No Action Alternative in January and February with differences up to ten feet.

Fry sometimes also stay in the gravels and could become stranded as well. The wet years would have steeper and deeper reservoir draft than the No Action Alternative and would result in increased stranding of burbot eggs. Burbot spawn in the Columbia River above Lake Roosevelt and in reservoir towards the upper end; the river spawning fish would not be as susceptible to reservoir fluctuations.

Kokanee are very sensitive to water temperature, and during summer are found at depths below 120 m to find suitably cool water. Similar to the No Action Alternative, Lake Roosevelt is very weakly stratified but does have suitably cool water at this depth along with suitable levels of DO. Lake whitefish and mountain whitefish also likely use this cool water in the summer.

Non-native warmwater gamefish, such as walleye, northern pike, smallmouth bass, sunfish, crappie, and others, as well as the prey fish that they eat (such as shiners, dace, and sculpins) all tolerate a wide range of environmental conditions and would continue to contribute to the fishery community under the No Action Alternative, and continue to adversely impact native species via predation. The invasion downstream by northern pike is of concern, and the Lake Roosevelt Co-Managers are actively suppressing pike populations using gillnets set by boats as soon as they can get on the water in the spring until the boat ramp becomes unusable at elevation of 1,235 feet. Under the No Action Alternative, this occurs on April 15 in wet years and ramps remain useable in dry and average years. Under MO4 in wet years, this would occur up to 6 days sooner, and in dry years the elevation could also drop to this level in May and June, though that is likely after pike would already have spawned. Like MO1, MO4 operations could preclude the ability for the pike suppression efforts for that time period when boat ramps would be inaccessible. For estimation purposes, one crew typically removes about 100 pike per week and they would operate three crews (Colville Tribe unpublished data), so opportunity lost of up to 6 days under MO4 in wet years and potentially some additional time in dry years could result in an estimated 300 or more pike not removed. It should be noted that is only one boat ramp, but the middle of Lake Roosevelt area becomes inaccessible earlier, at lake elevation 1,245' or slightly lower. Additionally, outflows and retention time would continue to influence the entrainment and downstream invasion of non-native gamefish below Chief Joseph Dam where ESA-listed anadromous salmonids would be susceptible to predation by them. During the time when pike juveniles would be most susceptible to entrainment (May to August), retention time under MO4 would be up to 30 percent lower and entrainment risk would be considerably higher than the No Action Alternative. Additionally, as adult pike distribution increases downstream in the reservoir, adults and juveniles both would become more susceptible to entrainment and the higher outflows any time of year would increase entrainment. Overall these effects would likely hasten the invasion of northern pike downstream, which could result in an increased risk of predation to salmon and steelhead.

Once released, the net pen fish that supplement the rainbow trout fishery in Lake Roosevelt would experience similar effects as their native counterparts except for spawning and early rearing effects. In addition, the net pen locations are situated where the water quality can be affected by changes in reservoir elevations; these fish are sensitive to temperature and TDG, and their eventual recruitment to the fishery can be affected by retention time coupled with reservoir elevation at the time of their release (McLellan et al. 2008), which is typically in May. Under the MO4, the water quality at these locations would be similar to the No Action Alternative except for modeled decreases in dissolve oxygen in the Spokane arm. This could decrease habitat suitability for the fish in that location. The operators strive to release these fish to coincide with the initiation of reservoir refill when outflows are reduced, which under MO4 wet and average years would be similar to the No Action Alternative and these fish would continue to be release when water quality conditions would be suitable. In dry years, however, initiation of refill would be delayed by up to four to six weeks later than the No Action Alternative. This delay would result in releasing hatchery fish later where they would likely encounter more stressful rearing conditions with higher temperatures and TDG. If the fish were released at similar time as the No Action Alternative but the refill is delayed, these fish would be subject to much higher risk of entrainment due to low retention times and higher outflows in May and June. Conditions in dry years would already be stressful to fish, and these conditions would be exacerbated by the delay in release.

The fish in Rufus Woods Lake would continue to be supplemented by entrained fish out of Lake Roosevelt to a large extent, with fish mostly entrained during the spring freshet and winter drawdown periods. MO4 operations would likely considerably increase entrainment in spring and summer, boosting fish populations in Rufus Woods Lake, where decreased outflows in August and September likely would decrease entrainment. This lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short retention time and low productivity. High flows during late spring and early summer would continue to flush eggs and larvae from protected rearing areas similar to the No Action Alternative, but at a higher magnitude in dry years. Median peak outflows occur in early June and would be about 3 percent lower than the No Action Alternative in wet and average years but higher in dry years. TDG in the Grand Coulee tailwater is a concern for fish in Rufus Woods Lake; modeling showed TDG would be lower than the No Action Alternative.

***Chief Joseph to McNary Dam***

<u>Summary of Key Effects</u>

Changes in key effects to fish and aquatic resources in this reach of the Columbia River under MO4 relative to the No Action Alternative include slight decreases in flows during May and June and minor increases in water temperatures during June and July similar to effects seen for MO1. In addition, seasonal fluctuations in water levels could occur in the McNary pool.

<u>Habitat Effects Common to All Fish</u>

The main habitat effect common to all fish under MO4 would be the greater degree of McNary pool fluctuation under this alternative. MO4 allows for a drawdown of 1 foot on average years, while on the driest years there may be a drawdown of 3.5 feet. This level of drawdown could adversely impact shallow water rearing and nesting habitats for warm water fish species and shallow water macroinvertebrates.

<u>Bull Trout</u>

Under MO4, there would be slight increase in water temperature in June and July. These higher temperatures may have minor added stress to bull trout and may induce them to leave the mainstem earlier in the year when compared with the No Action Alternative.

<u>Other Fish</u>

Key effects to white sturgeon from MO4 would include slightly lower spring peak flows in most years and slightly higher water temperatures upstream of McNary pool when compared to the No Action Alternative. In low water years there would be higher flows in May and June than the similar type of years in the No Action Alternative. While this may provide a minor survival benefit, sturgeon spawning and recruitment would not be successful in low water years of either alternative. The number of days in the year when water temperature would be over 21°C was used to evaluate temperature effect to white sturgeon. Under the No Action Alternative, there were about 5 days over this threshold while there were over 11 days under MO4. The effect of this change in water temperature would be a minor increase in risk of mortality to white sturgeon under this alternative.

Key effects of MO4 to fish species in this reach of the river that differ from those of the No Action Alternative include a slight increase in survival of juvenile salmon and steelhead that would increase forage for resident predator species, and potential McNary pool water level drawdowns of 1 to 3.5 below current operations that may affect rearing and survival of some warm water fishes. Under MO4 juvenile salmon and steelhead survival would be expected to increase by about 1 percent and provide an increase in forage for walleye, smallmouth bass, and northern pikeminnow. Currently, water levels are held relatively stable at McNary pool. Under MO4, there could be a drawdown during May and June of 1 foot in most years and up to 3.5 feet in dry years. This drawdown could leave smallmouth bass nests and walleye rearing areas dry and reduce egg and fry survival for these and other shallow nesting or rearing species.

**Region C**

***Snake River Basin***

<u>Summary of Key Effects</u>

Changes in key effects to fish and aquatic resources in this reach of the Snake River under MO4 relative to the No Action Alternative include increases in spill and TDG concentrations March through August and a potential to delay upstream dam passage for bull trout or other migratory species.

<u>Habitat Effects Common to All Fish</u>

The habitat effects common to all fish under MO4 would be the greater exposure to elevated TDG concentrations that results from increased spill.

<u>Bull Trout</u>

Effects of MO4 to bull trout in the Snake River that differ from the No Action Alternative include additional spill that may cause delays in bull trout upstream passage at the dams in May and June when the fish are moving out of the system to avoid warming water temperatures.

Elevated TDG levels from spill under MO4 may adversely affect an unknown number of bull trout in the reservoirs by degrading feeding, migrating, and wintering habitat in the mainstem Snake River. Under MO4, a total of 48.3 percent of all modeled days from November through June would have TDG concentrations over 110 percent, which is the highest number of all the MOs and exceeds the No Action Alternative by more than 10 percent. Higher TDG may affect bull trout in May and June when they are leaving the system.

<u>Other Fish</u>

Under MO4, white sturgeon fry would experience an increase in exposure to high TDG from April through July and a major increase in parts of April and May relative to the No Action Alternative. Modeling shows under MO4 TDG levels would be greater than 120 percent for 52.9

percent of that time period, with a high of 136 percent TDG. This is an increase from only 9.8 percent under the No Action Alternative and is also higher than any of the MOs. This would likely have adverse effects on white sturgeon fry.

Other resident fish would be affected by TDG as well. When compared with the other MOs, warm water fish species that rear near the surface would be subject to increased TDG Exposure in their rearing habitat from April through July and major increases in parts of April and Mary when compared with the No Action Alternative.

**Region D**

***Mainstem Columbia River from McNary Dam to the Estuary***

Summary of Key Effects

Bull trout would continue to use the Columbia River in limited numbers and seek thermal refugia available at the mouths of tributaries. White sturgeon could continue to successfully reproduce in years with adequate flow and temperature conditions (sturgeon recruitment failure could continue to occur independent of CRSO operations).

Habitat Effects Common to this Fish Community

Outflows from McNary Reservoir influence some of the fish relationships described in this section. Peak spring flows affect habitat maintenance for some species. Modeled median outflows for MO4 are shown below. The percent change compared to the No Action Alternative is shown in parentheses.

- April: 186000 (-3 percent)
- May: 255800 (-2 percent)
- June: 282700 (-1 percent)
- July: 198500 (no change)

Other flow parameters referred to in this section refer to outflows of McNary Dam, which are indicative of flows on downstream through the other projects.

Bull Trout

Bull trout are known to use the mainstem Columbia River to move between tributaries and have been observed at Bonneville Dam and McNary Dam in the spring and summer (Barrows et al. 2016). Water temperature is the most important habitat factor for bull trout in the mainstem Columbia. Under MO4, bull trout would continue to use the mainstem Columbia for migration between tributaries, as well as tributary mouths for passage and thermal refugia.

Adult bull trout move downstream during fall and overwinter in reservoirs (October to February; Barrows et al. 2016). Although bull trout successfully move between areas on the mainstem, their migration can be delayed at the dams. MO4 includes structural measures for additional spillway passage at McNary and John Day Dams. This measure would be in operation from March 1 through August 31, and could slightly improve bull trout downstream passage, but the majority of adult bull trout would have moved out of the mainstem by the time this surface passage route would be in use.

Passage through turbines can cause injury or mortality. MO4 includes turbine replacement with IFP turbines, which would improve survival (Deng et al. 2019). At John Day, turbine replacement would provide safer passage for any bull trout that move through the dam.

Bull trout would continue to be subject to bird predation under MO4 at similar levels to the No Action Alternative.

<u>Other Fish</u>

Under MO4, spawning and recruitment of white sturgeon would be similar to the No Action Alternative in average and wet years. In years of low flow conditions, water temperatures could increase beyond the suitable range by early June, resulting in little or no recruitment. White sturgeon spawning generally occurs in areas with fast-flowing waters over coarse substrates (Parsley et al. 1993). Minor changes in outflow under MO4 would not be large enough to cause discernable velocity changes that would affect sturgeon spawning habitat. Lack of effective upstream white sturgeon passage for all age classes decreases the connectivity of the population (Parsley et al. 2007). Under MO4, improvements to turbines at John Day Dam could reduce injuries and mortality of sturgeon.

White sturgeon larvae are adversely affected by TDG. Adults are more able to compensate for increased TDG by moving to lower depths, but larvae in shallow water would be more affected. Under MO4, TDG rates would be higher than No Action Alternative. All four dams in this reach would have a prolonged increase of TDG from 120 percent to about 125 percent TDG. This would result in detrimental effects to juveniles and larvae. Changes in a pool or tailrace elevation can affect juvenile white sturgeon through stranding in shallow water. Under MO4, John Day, The Dalles, and Bonneville Dam would all draw down to the minimum operating pool from late March to mid-August. This would be unlikely to result in stranding, since the drawdown would occur before spawning, but it could result in less shallow water habitat being available for juvenile and larval sturgeon.

Under MO4, no changes to other resident fish communities would be expected, though all fish would be subjected to higher TDG levels than the No Action Alternative. As shown above, outflow rates below McNary Dam would be very similar to the No Action Alternative. Water quality and food availability would also be similar to the No Action Alternative.

Conditions that promote lower water temperatures and higher spring flows tend to lower the survival rates of warmwater game fish, potentially lowering populations of predators on salmon and steelhead. MO4 would be expected to continue supporting warmwater game fish at levels similar to current conditions. Increased spill under MO4 could have slight adverse effects on northern pikeminnow.

**MACROINVERTEBRATES**

Below is a discussion of the macroinvertebrates in Regions A, B, C, and D under MO4. For more detailed information on the effects of MO4 on aquatic invertebrates and implications on food web interactions see the Habitat Effects section of these respective fish community analyses in the Resident Fish section under the applicable region.

**Region A**

At Hungry Horse reservoir, the wet and average years operations under MO4 would be similar in operations to MO1 (see the discussion of macroinvertebrates in Section 3.5.2.3). In dry years, the reservoir would be drafted much deeper with higher outflows in the summer months. The varial zone that provides benthic insect production would be appreciably reduced due to steeper drafts in the summer and lower elevations through the winter months, and aquatic insects in this zone would become dewatered faster than under the No Action Alternative. The reservoir would miss filling in 15 more years out of 100 compared to the No Action Alternative, and the elevation at the end of September would be 4 to 5 feet lower than the No Action Alternative in wet and average years, but up to 16 feet lower in dry years. Habitat for aquatic insects would be considerably reduced in these years, and benthic insects would be dewatered in a larger area.

With lower summer elevations, the area available for summer zooplankton production would decrease by up to 89,500 to 158,000 acre-feet, or by about 7 percent to 13 percent. Additionally, zooplankton would be flushed out of the reservoir and downstream at a rate that would be much higher than the No Action Alternative in July, August, and September of all years. Fewer zooplankton would be flushed out of the reservoir, compared to the No Action Alternative, in spring, fall, and winter. These outflow changes would increase zooplankton levels and wetted area for macroinvertebrate production in the South Fork Flathead River but could also flush more out of South Fork Flathead River with higher velocities. This pattern would continue (though at reduced levels) into the mainstem Flathead River.

MO4 operations would result in minimal changes to Flathead Lake, but the lower Flathead River would see 5 to 12 percent higher flows in August and 6 to 7 percent higher in September. These flows would potentially flush macroinvertebrates, including opossum shrimp, out of Flathead Lake, and increase habitat in the lower Flathead River for invertebrate production. The Clark Fork River macroinvertebrate communities would be similar to the No Action Alternative.

The operations of the Albeni Falls Project would be similar to the No Action Alternative in wet and average years, where operations would not result in appreciable changes to Lake Pend Oreille or the Pend Oreille River, nor the macroinvertebrate communities in those habitats. In dry years, however, Lake Pend Oreille would fill to elevation 2059.7 feet, which is about 2.5 feet lower than the No Action Alternative. This would result in a reduction of habitat available for aquatic macroinvertebrates through the summer. However, the No Action Alternative elevation drops about a foot through the month of September where the MO4 elevation would hold steady, so the aquatic macroinvertebrates produced would not experience the dewatering event as in the No Action Alternative. Increased outflows from mid-May through June would flush more zooplankton past the dam, but this would be reduced with lower outflows in September. These higher May-June flows would benefit macroinvertebrates in the Pend Oreille River as the river levels would hold about 10 percent higher for about a six-week period rather than dropping and dewatering habitat as in the No Action Alternative.

In the Kootenai Basin, Lake Koocanusa would not have any days over where the water elevation would be greater than 2,450 feet in average or dry years. In average years, MO4 operations result in a median minimum pool elevation from 4 to 5 feet lower than the No Action Alternative throughout the summer months. The rate of drop through the summer would be similar to the No Action Alternative in average years. In the winter months, the water elevation would drop at a less steep rate than the No Action Alternative. This operation would decrease the overall productivity of zooplankton and macroinvertebrates in the system overall through the warm, productive summer months. In average years, the benthic production would be at a lower level than the No Action Alternative but not subjected to any additional dewatering in summer, and fewer insects would be dewatered in the winter months compared to the No Action Alternative. In dry years, however, the pool level would be similar to the No Action Alternative in early July, but drop at a much steeper rate and end the water year a median of 13 feet lower than the No Action Alternative, exposing more varial zone as the summer goes on and dewatering a large portion of the insect production that would have established in the top thirteen feet of the inundated area.

**Region B**

The Columbia River from Canada to Lake Roosevelt would continue to produce benthic aquatic insects such as stonefly, caddisfly, and mayfly larvae. The river elevation in this reach is influenced by Lake Roosevelt operations and inflows so is somewhat variable, which would constrain benthic production to some degree in a reduced capacity.

MO4 operations would change river elevations at the U.S.-Canada border throughout much of the year and differ by year type. Wet and average years would be somewhat similar to MO1, with lower elevations in the winter (see the discussion of macroinvertebrates in Section 3.5.2.3). MO4 would result in water elevation drops compared to the No Action Alternative, with the stage dropping from the beginning of November through March in all year types, and there would be more fluctuations in stage. Steeper drops in water elevation and more variability would reduce suitable habitat for macroinvertebrate production and cause multiple desiccation events, likely limiting productivity in winter. Additionally, dry years would see river stage elevations a median of about 5 feet lower than the No Action Alternative from late June through October. This would limit habitat for the production of macroinvertebrates in the summer in dry years. Wet and average years would also be lower than the No Action Alternative, but only about 2 to 3 feet. This change in elevation represents the vertical feet; actual habitat dewatered would depend on the slope of the riverbanks at this elevation. As the river flows downstream closer to Lake Roosevelt, the pattern is the same but the additional drop from MO4 in dry years would result in about sixteen feet lower elevation at river mile 720.

This would indicate the magnitude of lost benthic habitat and desiccation would become increasingly severe as the river experiences more influence from Lake Roosevelt fluctuations.

Generally speaking, under MO4 median retention time would be considerably lower than the No Action Alternative during critical time periods for a number of fish relationships. In dry years, retention time would be much lower in May-August (29 percent, 28 percent, 21 percent, and 11 percent medians in May, June, July, and August, respectively). These reductions of up to 9 days retention time could greatly affect production and entrainment of zooplankton in the reservoir. It would be moderately higher in September and October and moderately lower in winter. In average years, retention time under MO4 would be 3 percent to 9 percent lower than the No Action Alternative in the critical spring/summer months, and moderately higher in fall and moderately lower in winter. In wet years, the summer months would be similar or slightly less than the No Action Alternative, higher in October, and moderately lower through the winter. In wet years is when retention time is lowest because more water is moving through the system, and MO4 would reduce retention times even further in these years by up to 9 percent in February and by 3 percent to 9 percent in the entire period of December through May.

The elevations in Lake Roosevelt would follow the same pattern as in the river sections described above, with MO4 elevations dropping further through the winter and being more variable. In dry years, the summer elevation would continue to drop from May to July and would be up to 22 feet lower than the No Action Alternative in this time period. This would result in desiccation of more aquatic macroinvertebrates and overall decreased habitat, likely severely reducing benthic productivity in dry years. Wet and average year types would also see loss of benthic production but less severe. More than one back-to-back dry year would intensify these effects.

Downstream of Grand Coulee Dam, Rufus Woods Lake has more riverine characteristics with steep gradients and narrow canyon walls, making it more like a river than a reservoir, with short retention time and low productivity. Regarding aquatic insect production and desiccation, river stage at RM 594 in Rufus Woods Lake would also experience effects differently by year type. Wet and average years would be similar pattern at slightly lower elevation through the spring and summer, and then in November through March experience steeper drops and swings that are more variable in stage than the No Action Alternative. This would reduce production capability. In dry years, this pattern would be similar except for the months of May through June, when additional flow would be released, raising stage and increasing velocities above the No Action Alternative dry year levels, and then July through August would be lower. This late summer period drop in stage could dewater more aquatic inverts produced in May and June.

**Region C**

Dworshak Reservoir elevations would be the same as the No Action Alternative. Benthic production in the reservoir would continue to be low due to the extensive variation in water surface elevation, near-shore wave action that causes erosion, and the lack of aquatic plants along the shoreline. Likewise, outflows would be the same as the No Action Alternative. Benthic communities in the Clearwater River below Dworshak Reservoir would continue to be limited by unsuitably high flows in summer and late winter.

The macroinvertebrate community of the lower Snake reservoirs and river would continue similar to the No Action Alternative. Siberian prawns and opossum shrimp may continue to increase in the reservoir environments. The reservoirs would continue to provide habitat for clams, mussels, etc., as in the No Action Alternative, and crayfish would find ample suitable habitat in the rock and riprap of reservoirs. Soft substrates of the reservoirs would continue to be dominated by low species diversity, mostly worms. Harder substrates would provide habitat for a relatively poor diversity of aquatic insect larvae.

**Region D**

MO4 would result in only minor changes to flows or temperatures that could affect macroinvertebrate communities in the lower Columbia River. Very little benthic macroinvertebrate information is available for the lower Columbia River. Lake habitats in the impounded reaches would continue to support a low diversity of worms, benthic insects, and mollusks. In MO4, John Day, The Dalles, and Bonneville Dams would all draw down to the minimum operating pool from late March to mid-August. The drawdown period in late March would likely result in stranding and desiccation of considerable numbers of aquatic macroinvertebrates, but there would still be ample habitat to continue production.

**SUMMARY OF EFFECTS**

**Anadromous Fish**

MO4 includes structural and operational measures that were intended to increase adult salmon and steelhead returns through improved juvenile migration and survival. These measures include incremental improvements in powerhouse surface passage routes and improved survival of fish that go through the turbines. Large increases in spill compared to the No Action Alternative, lower river reservoir drawdowns, and additional flow augmentation in dry years would be expected to decrease the travel time of in-river fish and decrease powerhouse encounter rates. With the increased spill volumes, TDG exposure would increase substantially compared to the No Action Alternative. Structural measures such as powerhouse surface collectors did not result in substantial increases in juvenile survival or improvements in adult returns.

The potential benefits of MO4 for salmon and steelhead varies greatly depending on which model is used. The CSS model predicts large increases in Spring Chinook salmon and steelhead to the Snake River. These increases are predicted based on increased spill levels that would increase the number of fish passing via the spillways and avoiding powerhouses, which the CSS models predict would reduce latent mortality associated with CRS passage. Snake River spring Chinook and steelhead SARs are modeled to improve by 70-75 percent relative to the No Action Alternative.

The LCM predicts minor increases in benefits to Upper Columbia spring Chinook and steelhead (two percent relative increases in SARs and downstream survival). However, for Snake River spring Chinook, the model predicts that unless changes in passage through the CRS can increase ocean survival by 10 percent (i.e. latent mortality effects are decreased by 10 percent), the net impact to Snake River Chinook salmon would be adverse (a relative decrease in SARs of 12 percent). This potential decrease in overall adult returns is primarily driven by reductions in transportation rates due to high spill, a relationship that could be similar for Snake River steelhead.

MO4 also includes structural modifications to infrastructure at the dams to benefit passage of adult salmon, steelhead, and Pacific lamprey. The objective to improve resident fish for would not be met in the upper basin due to the deep drafts to the upper basin storage projects. There is also the potential for negative effects to resident fish due to increased prolonged exposure to elevated TDG levels in the lower basin.

Overall, predicted effects from this MO are expected to range from moderate adverse to major beneficial. These effects vary widely by species.

**Resident Fish**

MO4 has effects ranging from minor to major adverse for resident fish. In Region A, decreases in reservoir productivity are expected in all years and would be further exacerbated in wet years. A delay in summer productivity in the Kootenai River below Libby Dam would also adversely affect fish. Conversely, MO4 would have a greater potential for cottonwood establishment and riparian regeneration, a moderate beneficial effect, but flows would provide the least usable habitat for bull trout, redband rainbow trout, and westslope cutthroat trout of all the MOs. At Hungry Horse Reservoir, moderate to major effects from decreased reservoir levels and increased summer outflows in dry years include loss of productivity, diminished tributary access, increased entrainment, and degraded habitat in the Flathead River. In most water years, these effects would be similar to MO1; in dry years, they would be more adverse due to releases to support downstream flow augmentation. In areas such as Lake Pend Oreille, lower reservoir elevations in dry years may limit access to tributary habitats and reduce the quantity of important shallow water habitats. Increased TDG associated with higher levels of spill may have effects on bull trout during months where they are leaving the system. 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. Changes in retention time would reduce food availability and increase loss of fish through Grand Coulee dam. This increased entrainment would likely hasten the invasion of northern pike downstream with increased entrainment and reduced suppression capability. Tributary access for wild fish spawning and water quality for net-pen raised fish would both be affected, and more eggs would be affected by dewatering; potentially losing entire year classes of some species of native fish. In Regions C and D, resident fish would be affected by increased TDG.

**Macroinvertebrates**

Lower summer elevations in certain areas would reduce habitat for summer zooplankton production, while higher levels of flows during summer months would flush certain macroinvertebrates in areas such as Flathead Lake, while increasing habitat in areas such as the lower Flathead River for invertebrate production. Elevations at Lake Roosevelt would become more variable, reducing benthic productivity in dry years. In Regions C and D, elevations, flows, and temperatures would be similar to the No Action Alternative and would result in negligible effects. Overall, effects are expected to be minor to moderate.

### 3.5.4 Tribal Interests

Fish are of great cultural importance to tribes in the study area and have fundamental roles in diet, medicine, and cultural identity. For virtually all tribes in the region, fish are part of the history of subsistence and important to public health. The CRS dams are viewed by tribes as an impediment to the aquatic resources that are essential to the tribal way of life. For example, the lower Snake River dams are seen as an adverse impact for tribes that rely on the Snake River aquatic resources.

Each tribe has a personal, cultural, spiritual, and commercial connection with the rivers around them. For instance, the Kootenai Tribe of Idaho and *Yaqan Nukiy*, the main source of subsistence historically was fishing. The Kootenai River itself became part of the Tribe's identity and historically there were a number of camp locations along the River such as at Jennings, Montana.

This fish analysis evaluates how MOs impact survival of adult and juvenile salmon and resident fish in the study area in comparison to the No Action Alternative. In terms of how those MOs would impact Tribal Interests, the co-Lead Agencies assume that if more adult salmon, steelhead lamprey, and other anadromous fish are returning to the Columbia River and its tributaries and resident fish conditions improve, then there would be more fish available for harvest. However, because of the differences in life histories, habitat requirements, and effects across the four regions due to operations, the analysis and results are very complicated and effects to tribes would be based on location and the fish species important to that tribe.

In general, however, the analysis describes the following effects.

#### *3.5.4.1 Salmon and Steelhead*

In comparison to the No Action Alternative, Upper Columbia River salmon and steelhead would generally see similar or minor increases in juvenile and adult returns for MO1, MO3, and MO4 unless ocean survival improves dues to reductions in latent mortality. Tribal members that harvest these populations for subsistence, recreation, or commercial fisheries may see an increase in numbers of fish return, except under MO2. MO2 would result in decreased abundance for these fish.

Snake River salmon and steelhead would see minor improvements under MO1. MO2 would result in decreases in juvenile survival and adult abundance. MO3 would have short-term construction related effects but could lead to long-term increases in adult returns. Fall Chinook spawning habitat would increase. MO4 would increase juvenile survival, but adult survival could decrease. In addition to the differences in impact on tribal members that harvest these fish under each MO, there are also differences in the impacts within the MOs based upon which model has been used.

#### *3.5.4.2 Other Anadromous Fish (coho, chum, eulachon, green sturgeon, lamprey)*

MO1 would have minor decreases for coho and chum with mixed impacts for lamprey. Eulachon and green sturgeon numbers would be similar to the No Action Alternative. There would be decreased juvenile survival for MO2 for these species. Under MO3, there would be minor increases in abundance in the lower and middle Columbia reaches for eulachon and green sturgeon, while coho and chum would be similar to the No Action Alternative. MO4 would have minor benefits for lower and middle Columbia juveniles, but there would be corresponding minor adverse effects for chum and lamprey.

#### *3.5.4.3 Resident Fish*

Region A: MO1 and MO3 would have minor to moderate short-term adverse effects to bull trout, food webs, varial zones (important for migration), and habitat. MO3 would have riparian and sturgeon recruitment effects in the Kootenai River as well. MO2 and MO4 would have moderate to major effects in the same areas. MO4 would also have habitat and access issues in Lake Pend Oreille.

Region B: Effects from MO1, MO2, and MO4 would range from minor to major adverse effects to resident fish in Lake Roosevelt stemming from increased entrainment, varial zone effects (important for migration) and in the river reach, there would be minor reduction in sturgeon recruitment. MO3 would have minor adverse effects due to potentially increased entrainment, but would also have a major beneficial effect due to increased recruitment and connectivity for sturgeon in McNary Reservoir with minor short-term construction-related effects.

Region C: MO1, MO2, and MO4 would have minor to moderate adverse impacts to resident fish due to warmer summer water temperatures, reduced flows, increased entrainment, or increased TDG and GBT. MO3 would result in improved connectivity and increased recruitment for bull trout and white sturgeon and more native fish.

Region D: MO1 would have negligible effects to flows and water temperature; minor adverse potential sturgeon effects. MO2 and MO3 would have negligible effects to flow and water temperature. Under MO4, Negligible effects could be expected to flow and water temperature with minor adverse effects due to increased TDG.

All of these fish have economic, subsistence and culturally significant importance for tribes, and as shown, effects vary across the study area depending on species. Tribal Interests would be affected accordingly.

## 3.6 VEGETATION, WETLANDS, WILDLIFE, AND FLOODPLAINS

This section provides analysis for vegetation communities, wetlands, and wildlife, including special status species, and floodplains. It describes the existing vegetation and wildlife that may be affected by measures contained in the No Action Alternative and Multiple Objective Alternatives (MOs), including changes in operations (hydrology) and structures, or dam breach. Wildlife species are grouped into the following broad categories: birds, mammals, reptiles and amphibians, and invertebrates. Land cover with vegetation was grouped into the following broad categories: upland; wetlands-forested; and scrub-shrub, wetlands-emergent herbaceous. Land cover without vegetation was classified as barren zone. Changes in some key islands were also analyzed (i.e., Blalock Island, Crescent Island). Wildlife and plant species listed under the Endangered Species Act and their critical habitat are described separately below in Section 3.6.2.6. Floodplains are discussed in Section 3.6.2.5, Floodplains.

### 3.6.1 Area of Analysis

The CRS study area, or area of analysis, for vegetation, wetlands, wildlife, and floodplains consists of vegetation communities and habitats of the Columbia River Basin currently influenced by the operations of the 14 Federal projects (the CRS). Affected vegetation communities both downstream from the dams and the associated reservoirs upstream are included. The study area extends from the Flathead River, Clearwater River, and the U.S. portions of the Kootenai River, Pend Oreille River, Clark Fork River, the lower Snake River (inclusive of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite projects), and the mainstem Columbia River to the Pacific Ocean and includes the river channels and affected vegetation and wildlife. A map of the Columbia River Basin is included in Chapter 1 (Figure 1-1). Many factors including river flows, timing, duration, and water level affect the species composition and distribution of riparian and upland vegetation and wetlands habitats within the basin, which in turn influence the wildlife species selected for analysis.

The study area extent is generally based on the extent of the H&H model's study area (Section 3.2 and Appendix B, Part 3, specifically the extents of the hydraulic models used to develop water surface elevation data across the reaches between dams). These models were developed to capture inundated areas resulting from a wide range of potential flooding events.  See Appendix A for more information on the H&H modeling tools. For the Libby, Hungry Horse, Lake Pend Oreille, and Dworshak reservoirs, the study areas were based on reservoir operations and changes to full pool water surface elevations. These extents were chosen because they capture changes in water surface elevations that could influence wildlife populations or their habitats as a result of implementing the operational parameters detailed in each MO. Choosing this extent also provides consistency with other resources analyzed in this EIS and aligns with modeled information for the alternatives.

Individual study areas extend upstream from each project to the furthest extent of the reservoir at its maximum operating water level, or to the U.S.-Canada border. Where project operations have a meaningful effect on habitat conditions downstream from the project, the study area extends downstream to the upstream extend of the next downstream project. For example, for Hungry Horse, the study area includes the Hungry Horse reservoir as well as approximately 120 miles downstream of Hungry Horse Dam. The project area for John Day, a run-of-river dam, extends from John Day Dam upstream to the face of McNary Dam. The Dalles Dam. Figure 3-135 through Figure 3-147 show the projects and their associated study areas. Appendix F, Vegetation and Wildlife, provides more in-depth reach- and study area-specific information for vegetation, wetlands, and wildlife, including maps and a discussion of existing conditions.

For Figure 3-135 through Figure 3-147, much of the area designated as upland in these figures occupies the natural (pre-development) floodplain but is currently protected from flooding by levees and reservoir operations (Section 3.9.3). Portions of the areas that are designated uplands in these figures actually may lie in the active floodplain and wetlands, although these areas are likely to be infrequently flooded.

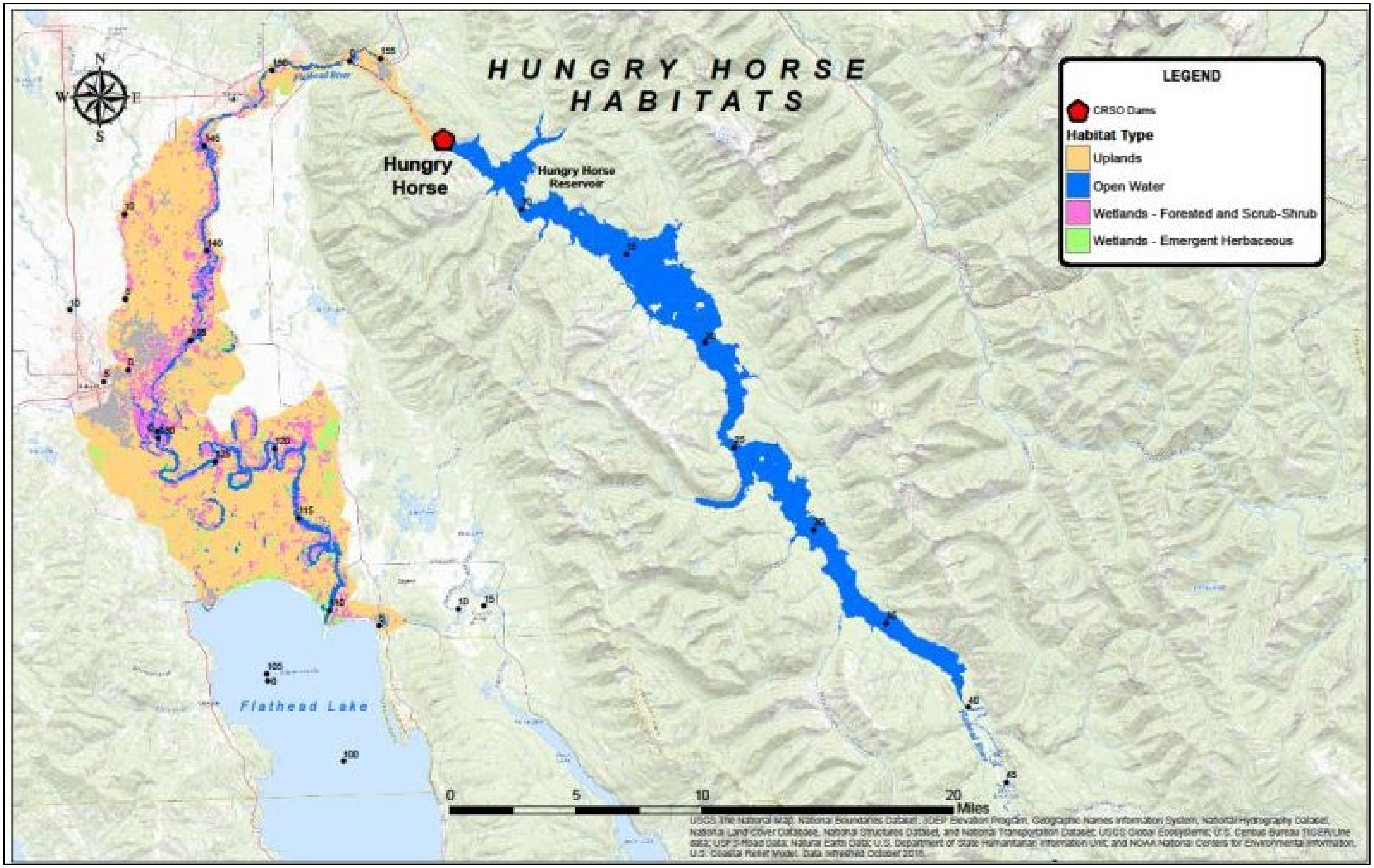
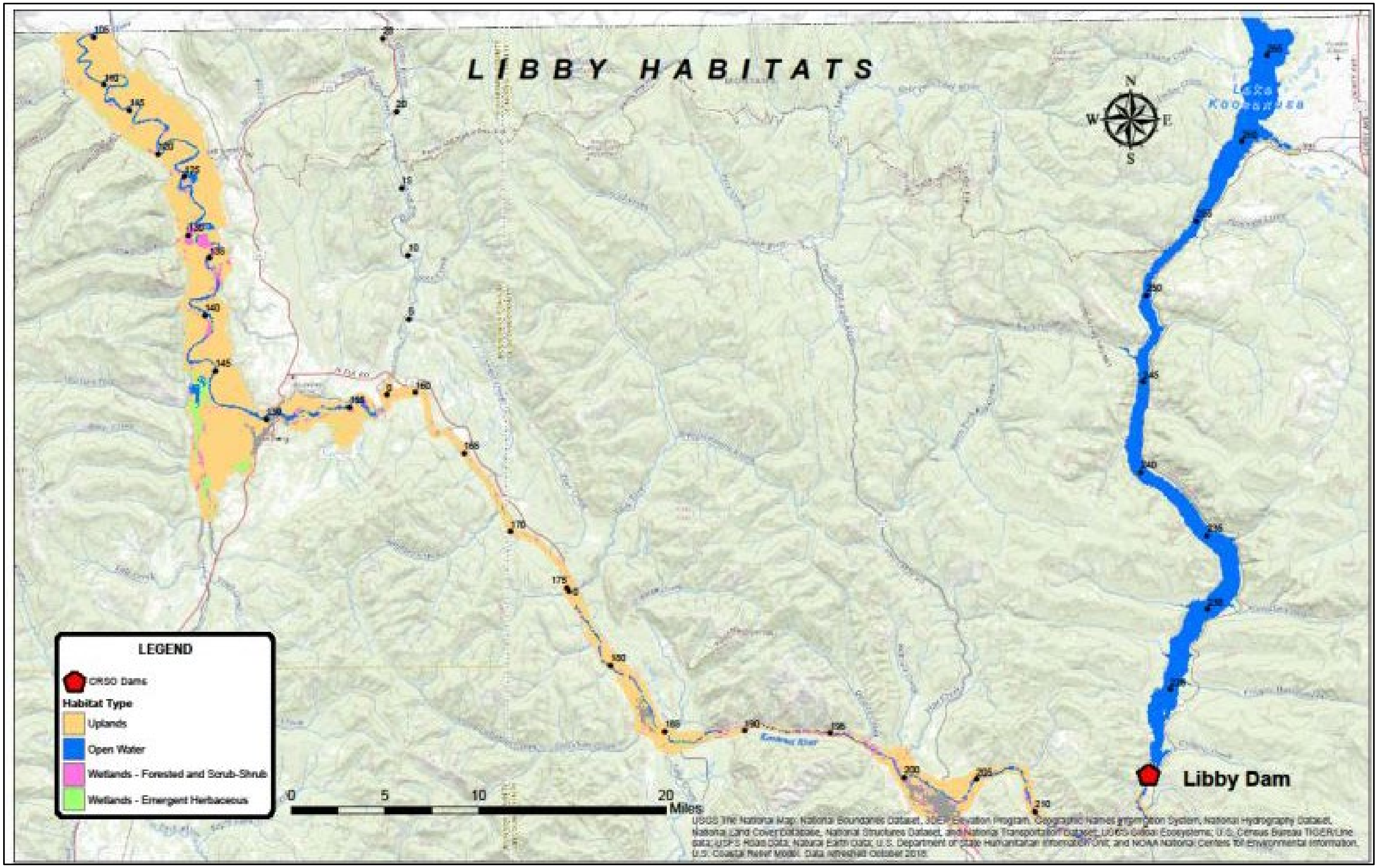



**Figure 3-135. Hungry Horse Study Area for Vegetation, Wetlands, and Wildlife**




20396
20397 **Figure 3-136. Libby Study Area for Vegetation, Wetlands, and Wildlife**

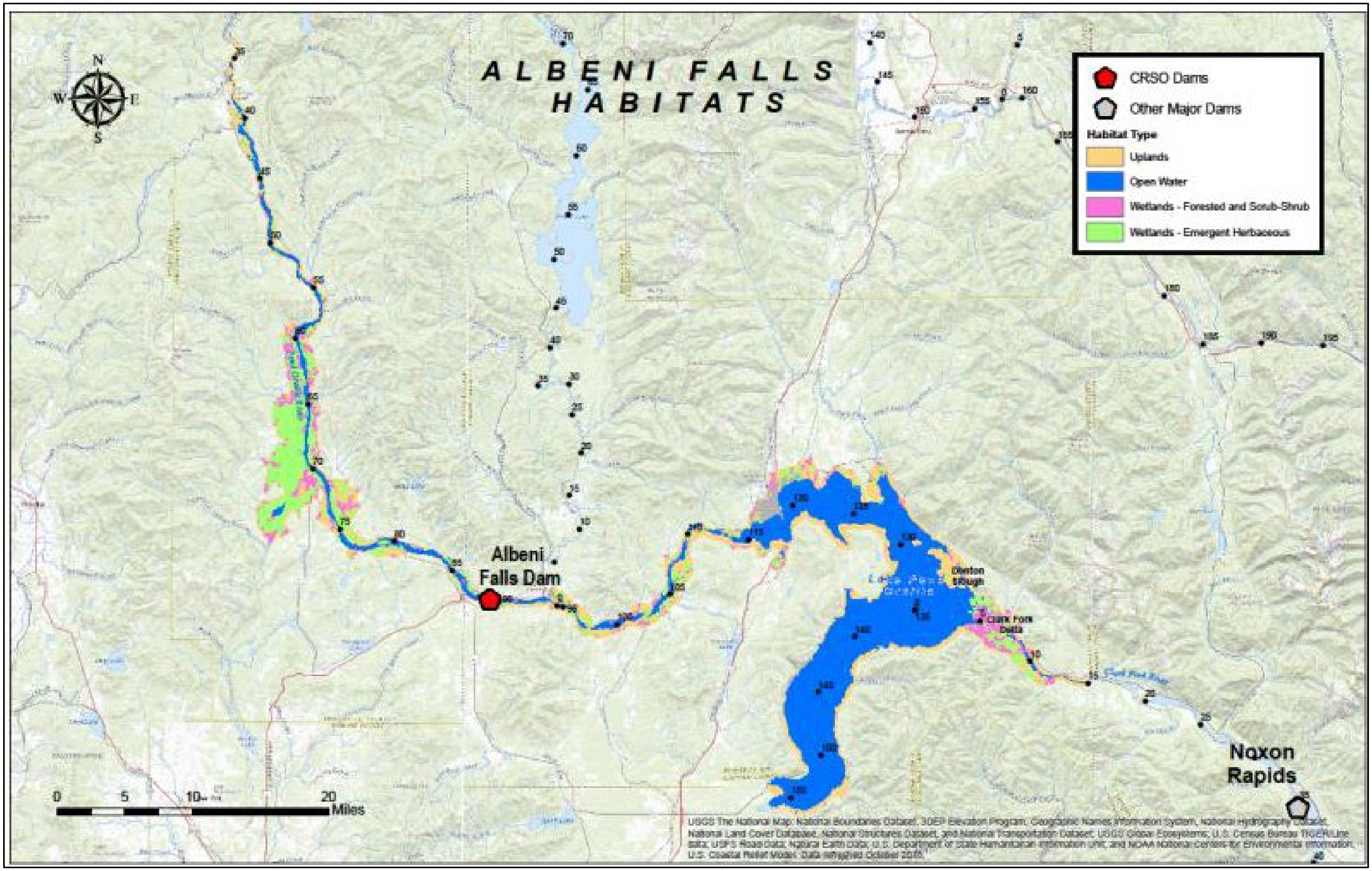



**Figure 3-137. Albeni Falls Study Area for Vegetation, Wetlands, and Wildlife**

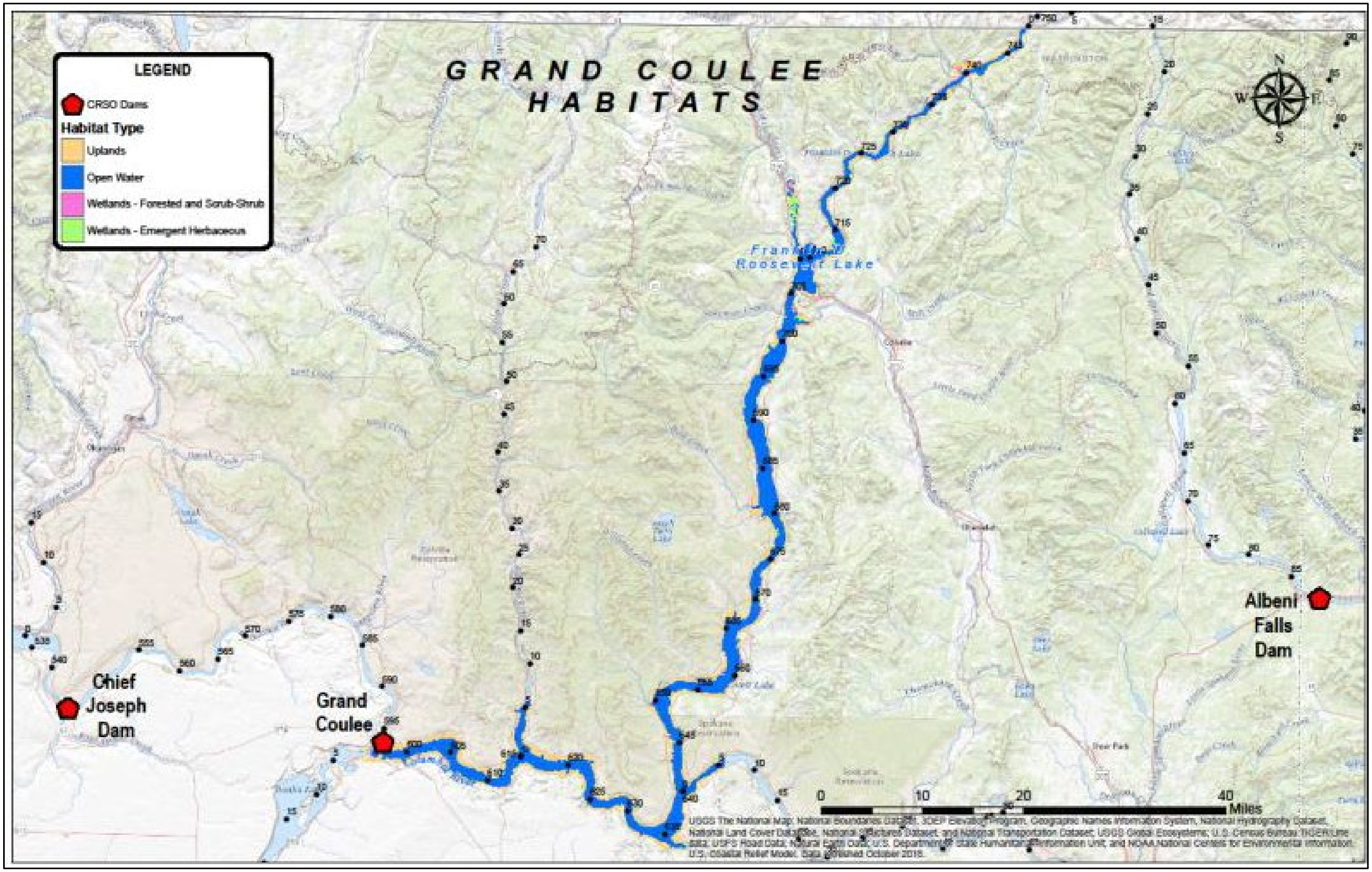



**Figure 3-138. Grand Coulee Study Area for Vegetation, Wetlands, and Wildlife**

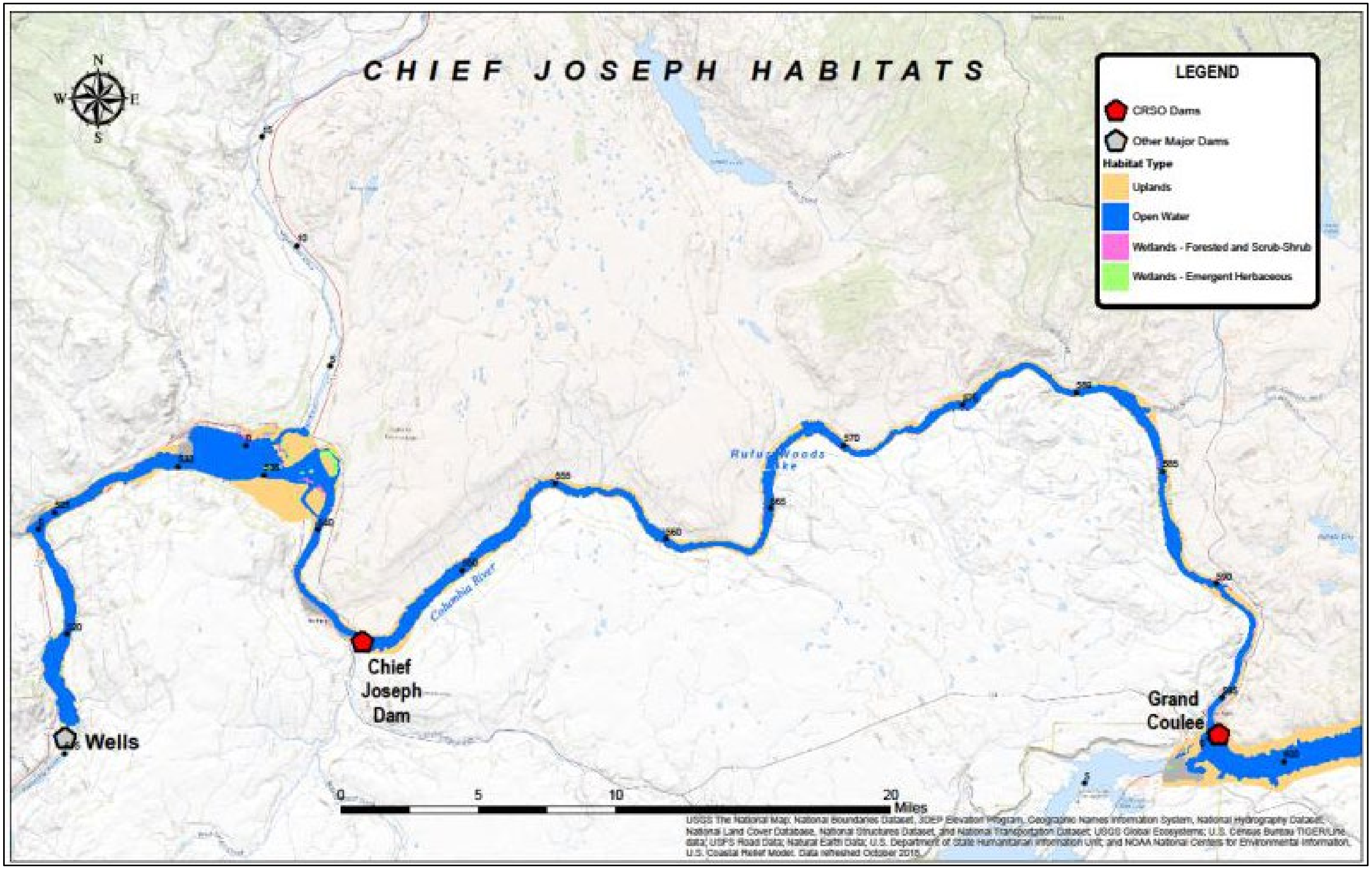



**Figure 3-139. Chief Joseph Study Area for Vegetation, Wetlands, and Wildlife**

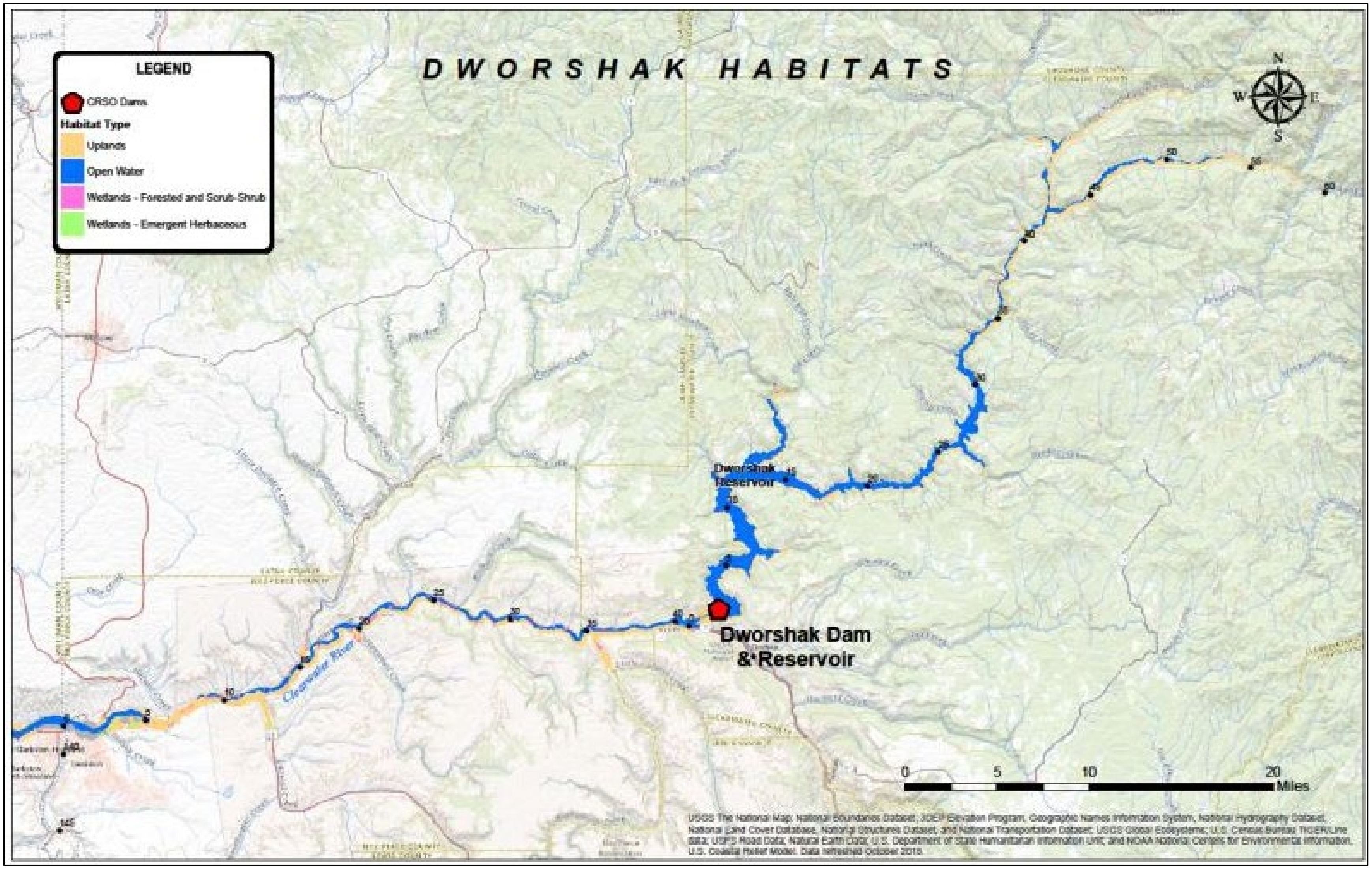
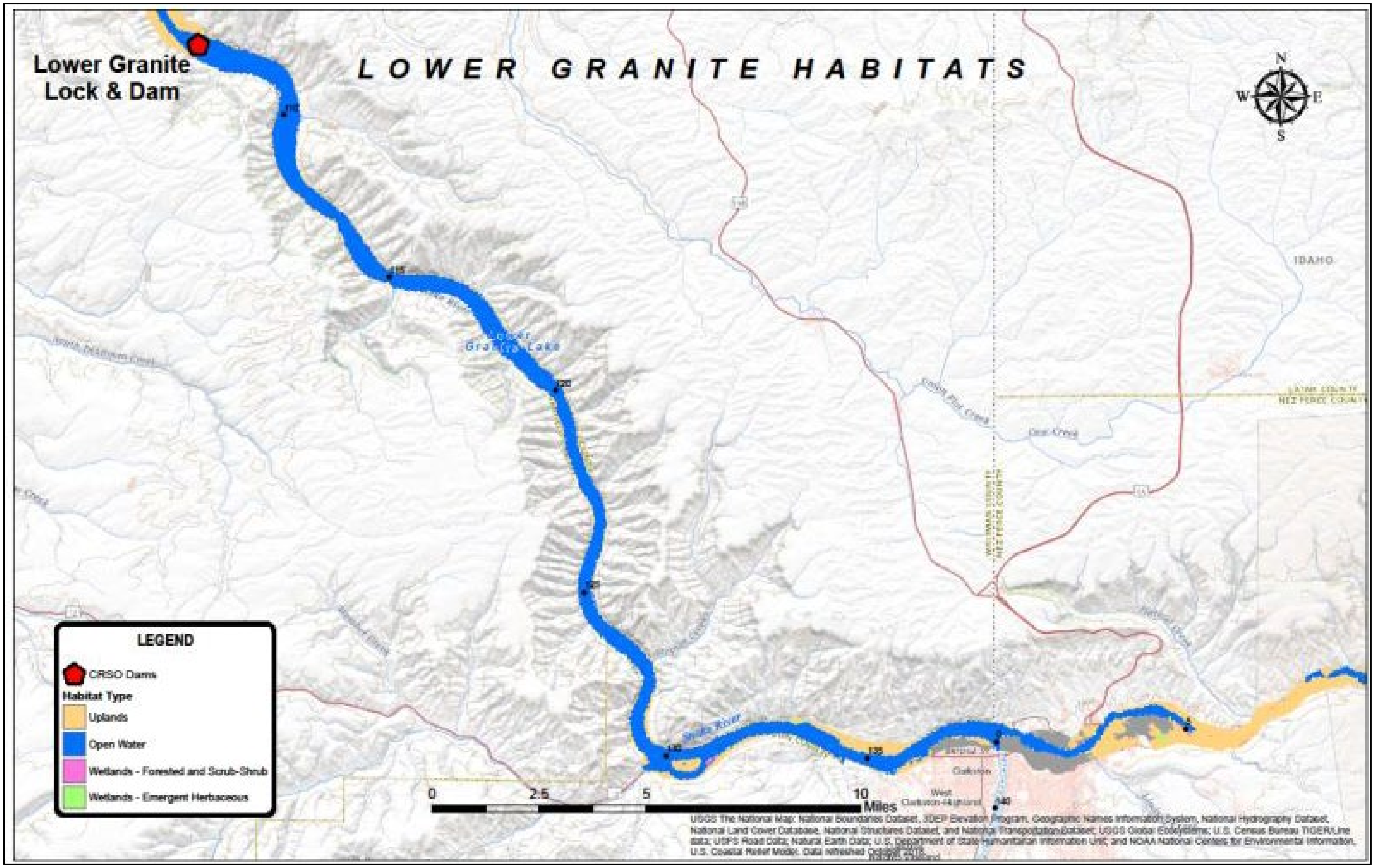



Figure 3-140. Dworshak Study Area for Vegetation, Wetlands, and Wildlife

20406



20407 **Figure 3-141. Lower Granite Study Area for Vegetation, Wetlands, and Wildlife**

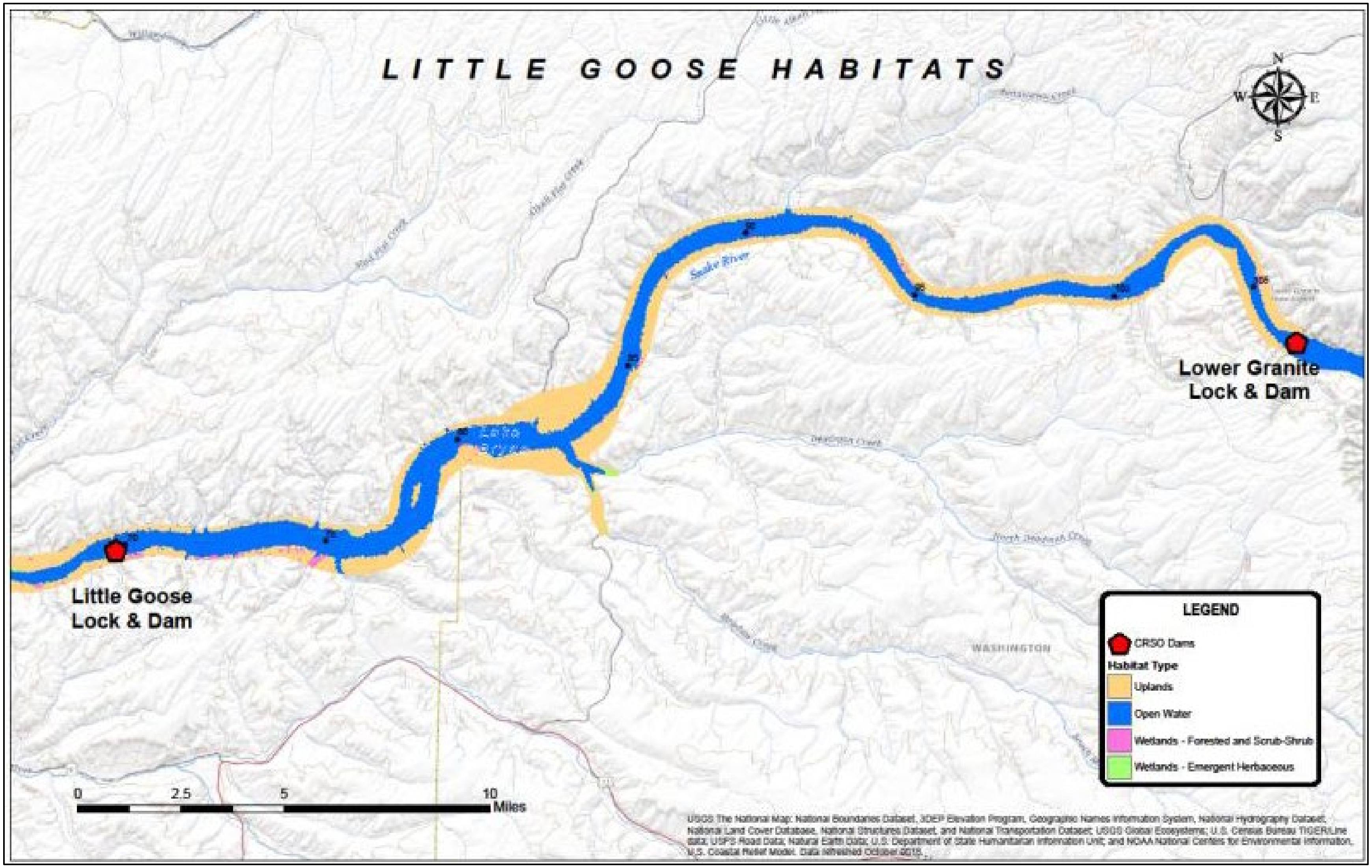



**Figure 3-142. Little Goose Study Area for Vegetation, Wetlands, and Wildlife**

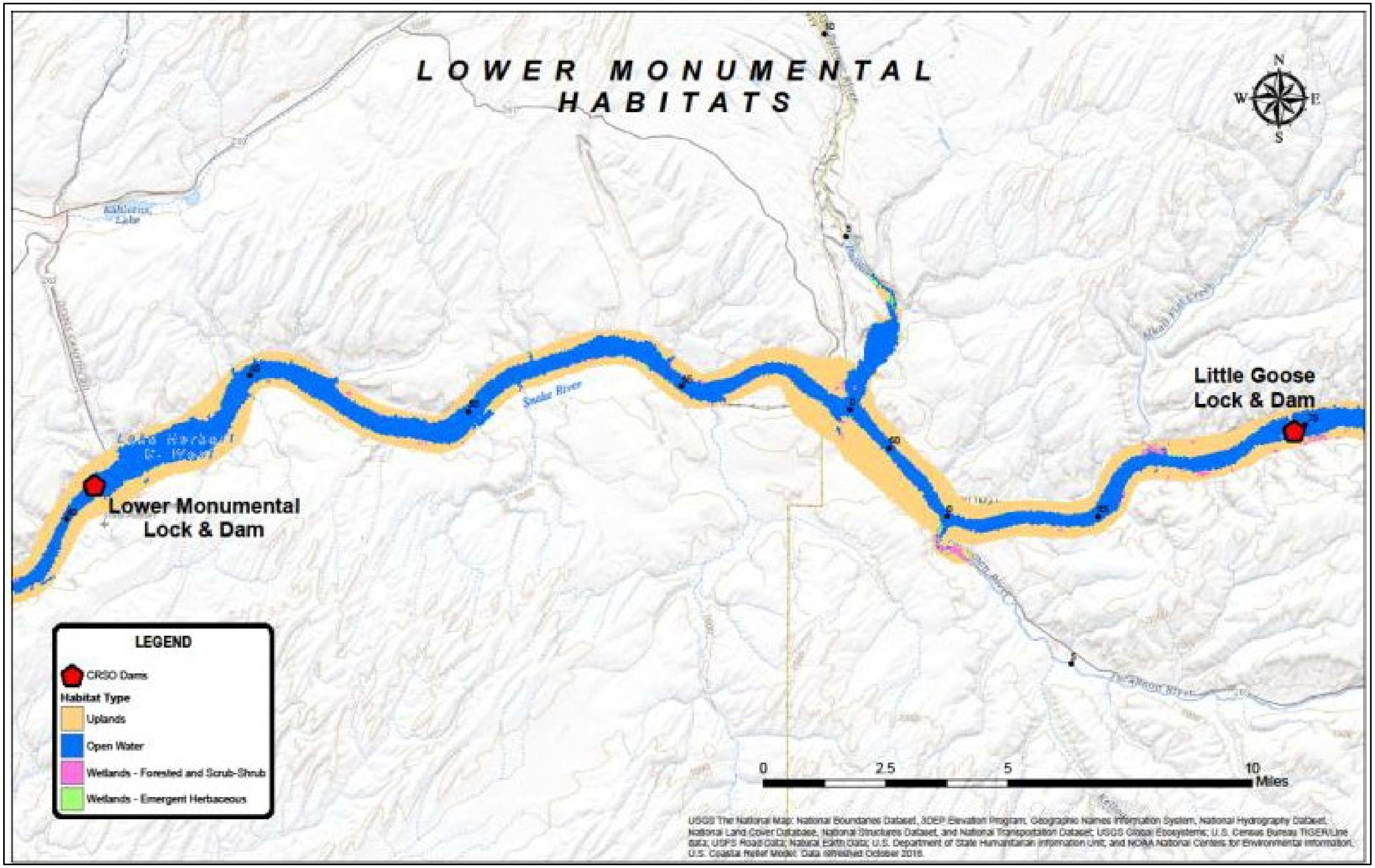



**Figure 3-143. Lower Monumental Study Area for Vegetation, Wetlands, and Wildlife**

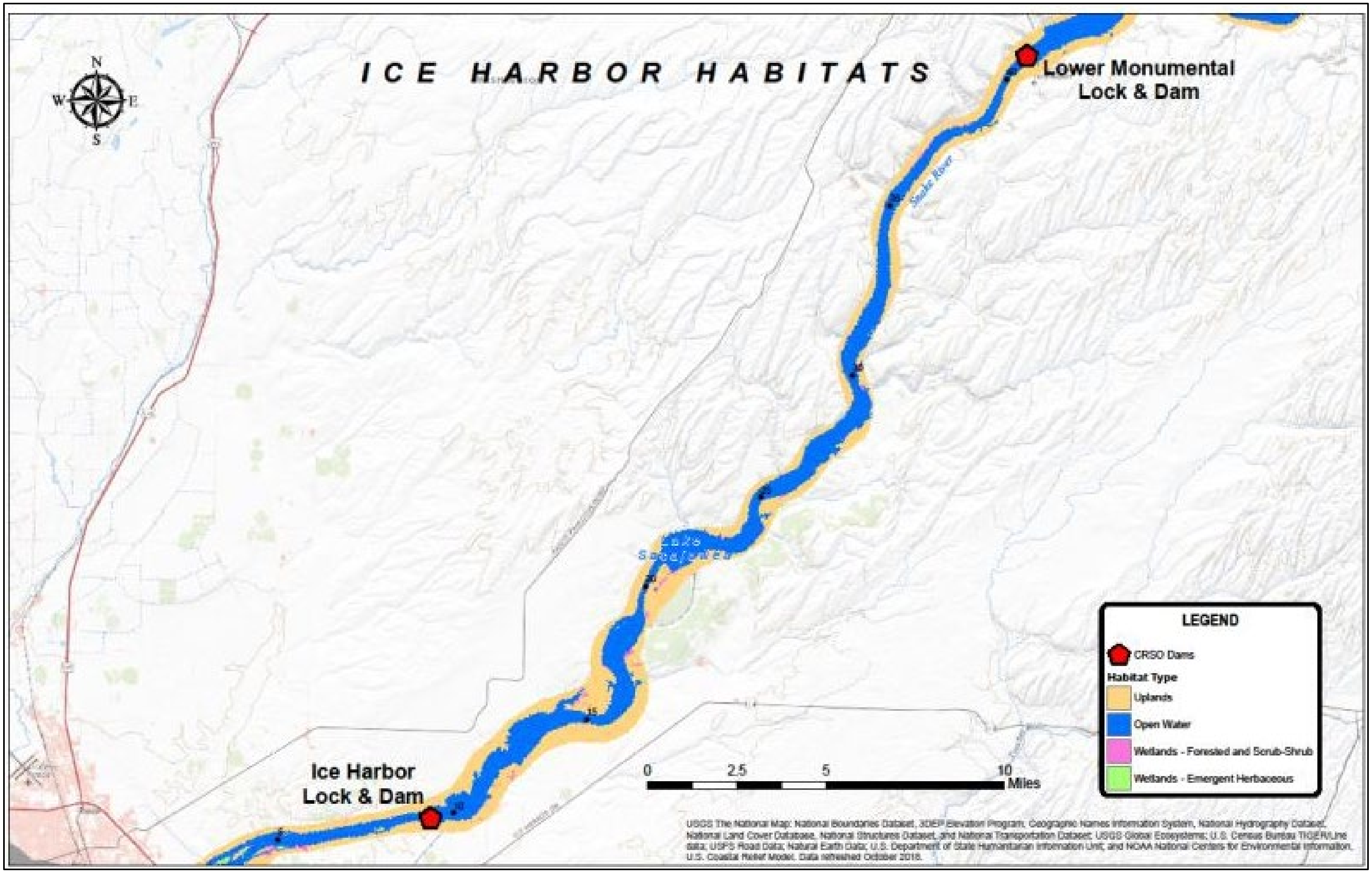



**Figure 3-144. Ice Harbor Study Area for Vegetation, Wetlands, and Wildlife**

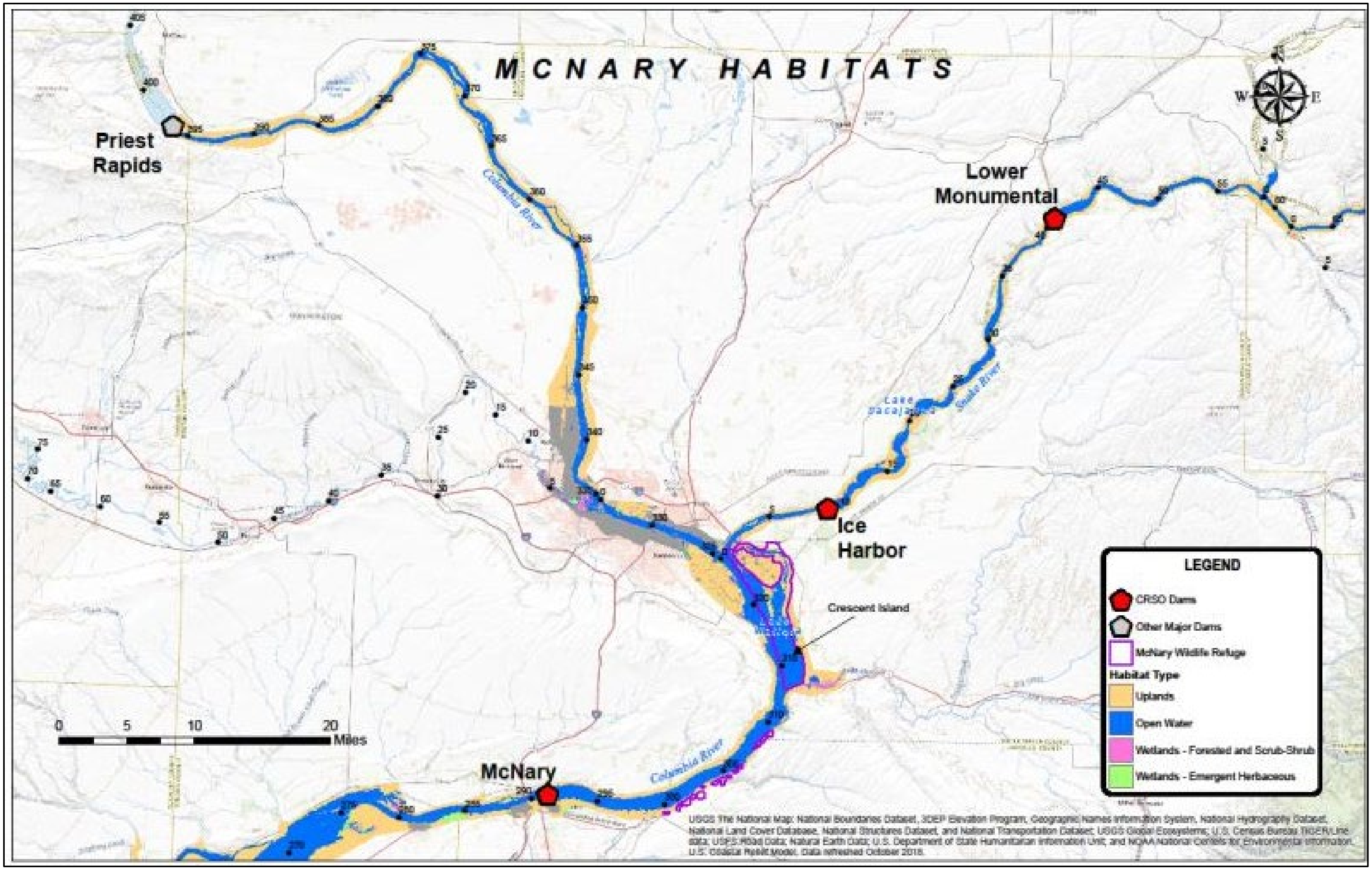
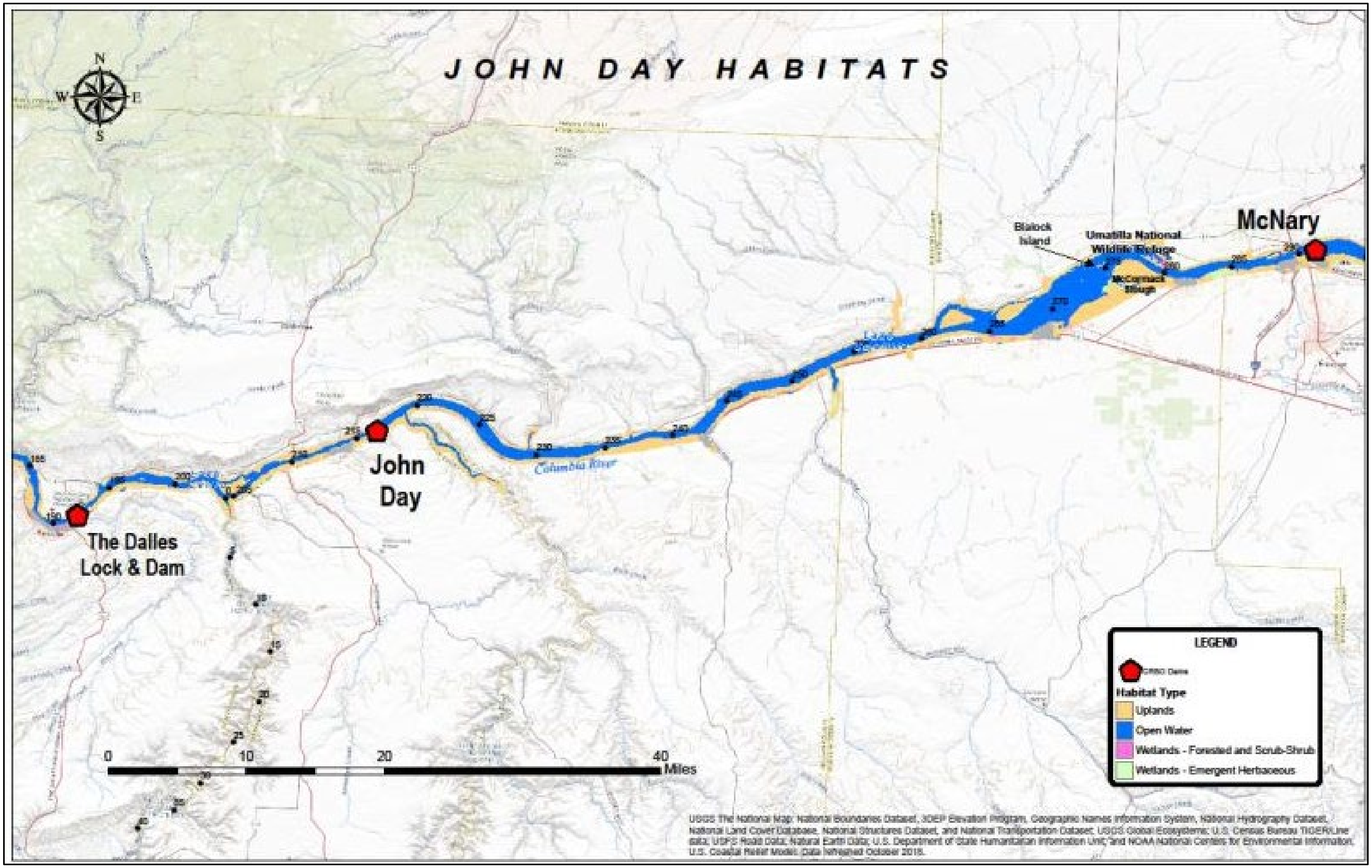
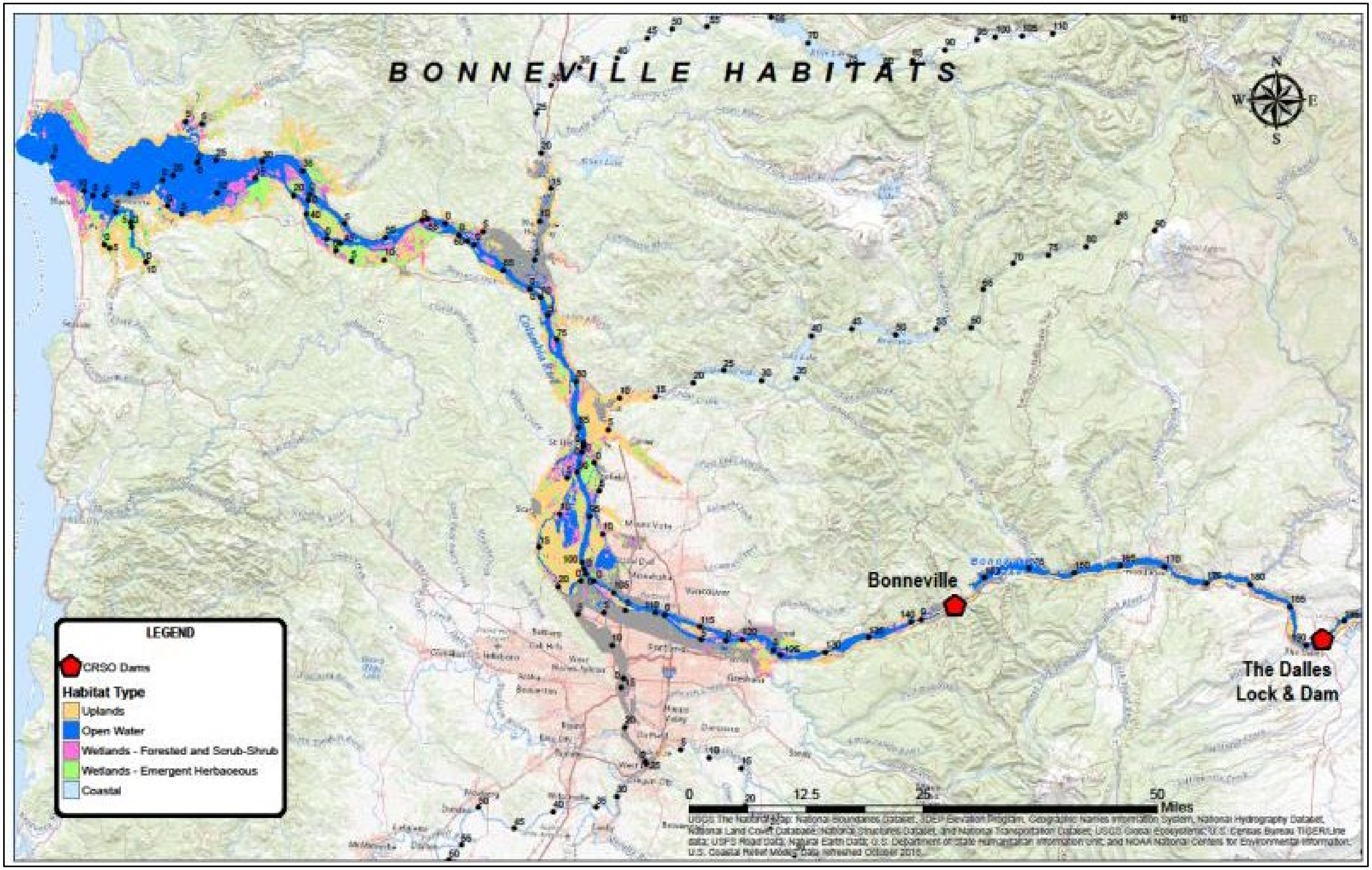



**Figure 3-145. McNary Study Area for Vegetation, Wetlands, and Wildlife**




20416
20417 **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**

## 3.6.2 Affected Environment

A diversity of plant communities and wildlife habitats are represented in the basin, including riparian and wetland habitats, sagebrush (*Artemisia* spp.)-dominated shrub-steppe communities, mixed coniferous and deciduous forests, moist coniferous forests, grasslands, and agricultural lands. These vegetation communities are specific to the local topography and climate ranging from the wet Pacific Ocean estuary located a few feet above sea level to the high elevation Rocky Mountains, to rich agricultural valleys, to the arid shrub steppe.

### *3.6.2.1 Vegetation Communities and Habitat Types*

Land cover types and vegetation communities, or habitat types, are used in this study as proxies for wildlife habitat. The diverse habitat types (e.g., wetland, upland forest) found throughout the basin are used by various wildlife species for breeding, nesting, feeding, or sheltering. Habitat types are differentiated from one another by their structure, form, and species composition, are shaped by climate patterns, substrate types, and disturbance regimes, and can be broadly defined by dominant plant species. The habitat types described herein are different from species-specific habitats, which are unique to individual species and may include multiple habitat types (e.g., wetlands, forests, marine systems) necessary to complete their lifecycle.

Two primary geographic datasets were used to identify land cover, vegetation, and wildlife habitat within the CRSO study area: the Northwest Habitat Institute (NWHI) habitat land cover classifications and the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI). These datasets were combined in a geographic information system (GIS) where the digital NWI data provided the source for all wetland habitats in the CRS study area and the NWHI dataset was the source for identifying all other habitat types across the CRS study area. More information on the NWHI and NWI are included in Appendix F, *Vegetation and Wildlife*.

Five habitat types were defined for this study: uplands, water, wetlands, barren zone, and islands. These habitat types, the focus of this analysis, are those that include habitat elements that are sensitive to changes in water surface elevation (WSE) and river flows. The NWI and NWHI datasets do not differentiate or show the barren area around reservoirs, nor do they delineate islands as such. Rather, the datasets display water up to the full pool elevation and vegetation coverage on islands. The proposed alternatives may affect WSE and river flows, potentially resulting in changes in the availability, accessibility, and distribution of these habitats, affecting a wide variety of wildlife species. NWHI habitats and NWI wetlands were combined based on types of ecosystems represented and functional groups. Developed and urban lands were not analyzed in terms of habitat effects as they were considered not to be sensitive to changes in water surface elevation or river flows under the proposed operations. Agricultural lands, on the other hand, can provide significant forage and cover (fawning, calving, nesting, and potential hiding and escape cover) for wildlife. However, they were not delineated as a separate habitat type nor were they analyzed as a stand-alone vegetation community.

**UPLANDS**

Upland areas consist of a wide variety of vegetation and wildlife habitat types. The term "upland" typically refers to lands above an alluvial floodplain or river channel. For this analysis, all lands that are not classified as barren, wetlands (including riparian areas), open water, coastal, or islands are considered uplands. Uplands in the CRSO study area include coniferous and hardwood forests, woodlands, grass and scrublands, shrub-steppe, and pasture or agricultural lands.

At Hungry Horse, Libby, Albeni Falls, Lake Roosevelt (upstream of Grand Coulee Dam), and Dworshak Dams, the upland areas are dominated by coniferous forests including ponderosa pine on the warm, dry exposed slopes and a mix including ponderosa pine, western larch, Douglas-fir, lodgepole pine, western hemlock, and western red cedar on wetter slopes, at lower elevations, and near the water's edge. Deciduous tree species such as black cottonwood, willow, and red alder are also found in areas near water. Understory shrubs include western serviceberry, bitterbrush, ocean spray, mallow-leaf ninebark, and snowberry.

From Grand Coulee Dam down through The Dalles Dam and lower Snake River Projects, upland areas are dominated by shrub-steppe vegetation. The shrub component is dominated by big sagebrush, rabbitbrush, serviceberry, currant, and antelope bitterbrush while Idaho fescue, Indian ricegrass, Sandberg bluegrass, Thurber's needlegrass, needle-and-thread, sand dropseed, bluebunch wheatgrass, and bottlebrush squirrel tail make up the primary native grass species. Common forbs include arrowleaf balsamroot, yarrow, various buckwheats, blanket flower, various parsleys, and lupine species.

Upland habitats in the Lake Bonneville study area are diverse and range between warm, dry shrub-steppe to wet, cool forests near the Cascade Range. Mountain hemlock forests transition to drier ponderosa pine and mixed Douglas fir and grand fir forests and then shift to Oregon white oak woodlands and grasslands at the lowest elevations. Deciduous trees include red alder, big-leaf maple, and smaller canopy trees such as cascara buckthorn. Understory shrubs and forbs in upland habitats may include salal, Oregon grape species, and swordfern.

**WATER**

The water cover type includes rivers and streams, lakes, reservoirs, bays, and estuaries. In the CRS study area, the water cover type (also referred to as open water) is composed primarily of the Columbia River and its major tributaries, and storage project reservoirs. Water is a cover type that is used by terrestrial and aquatic wildlife. Many types of wildlife species use open water as primary foraging habitats, migration corridors, or temporary refuge from predators.

Aquatic vegetation that is submerged for its entire lifecycle provides important food resources and shelter for several classes of vertebrates. The aquatic vegetation species commonly found in the CRSO study area are pondweed, parrotweed, duckweed, the invasive *Elodea*, knotweed, and milfoil. Aquatic stalked diatom known as Didymo has become established at a nuisance/noxious density in the Kootenai River downstream of Libby Dam and in localized areas in the Flathead River below Hungry Horse Dam.

**WETLANDS**

Wetland habitats are important ecological features providing a multitude of benefits to the human environment and a unique variety of fish, wildlife, and plant species that are adapted to survive at least part of their life cycle in aquatic environments. Wetlands can be classified based on a dominant vegetation (e.g., evergreen or deciduous) or exposed substrate type (e.g., cobble, gravel, bedrock). While local hydrologic conditions typically vary over time, plant species and soil characteristics tend to reflect the long-term hydrologic conditions of a site and can help identify wetland types when local hydrology is absent. These habitats are usually a transitional area between upland habitats and aquatic habitats. Because wetlands, including riparian habitats, are dependent on the duration of seasonal inundation, these habitats are sensitive to changes in project operations influenced by river flows and precipitation patterns. For this EIS, two types of wetlands are described below: forested and scrub-shrub, and emergent herbaceous. Newly exposed transitional areas that could develop into vegetated wetlands over time are referred to in this EIS as mudflats and could be composed of silty, clayey, or rock material. The length of time that the sediment is exposed would determine if vegetation would establish in these unvegetated sediments.

Riparian zones are transitional areas between flowing and non-flowing bodies of water and the upland terrestrial habitat. Riparian zones are frequently inundated and can contain wetlands. There is no generally agreed upon classification system for riparian vegetation, although a number of systems have been proposed and are in use by individual Federal, state, and local agencies. For the purposes of this EIS, riparian habitat is incorporated into the Wetlands – Forested and Scrub-Shrub section below.

**Wetlands – Forested and Scrub-Shrub**

Forested and scrub-shrub wetlands (riparian habitat) provide important feeding, sheltering, and breeding or nesting habitat for wildlife. The vegetation stabilizes river and stream channel banks and reduces erosion. Along rivers and streams, this vegetation provides a shade canopy over stream channels to reduce temperatures. In addition, this vegetation slows surface water and filters out sediments to improve water quality. Woody wetlands support a high diversity of wildlife.

Throughout the CRS study area forested and scrub-shrub wetlands adjacent to rivers are dominated by deciduous shrub and deciduous tree cover types with a dense understory of grasses, forbs, and shrubs. Cottonwood, aspen, alders, chokecherry, and willows, with some conifers, are common in the forested and scrub-shrub wetlands. Native shrub and undergrowth species typically include red-osier dogwood, mountain alder, gooseberry, various roses, common snowberry, various willows, and Douglas spirea. Himalayan blackberry, a non-native species, is a common shrub. Herbaceous species may include native forbs, grasses, and sedges, as well as invasive and non-native species such as reed canary grass, Western false indigo, flowering rush, yellow flag iris, purple loosestrife, and salt cedar.

**Wetlands – Emergent Herbaceous**

Emergent wetlands are limited in extent throughout the CRSO study area. They are restricted by the steep shorelines, seasonal drawdowns, and shorter-term fluctuations that also influence other habitat types. The emergent wetlands occur along the shoreline primarily in embayments, the mouths of small streams, and in the confluences of larger tributary streams and rivers.

Common plants present in emergent wetlands include cattails, horsetail, bulrush, and sedges. Invasive species such as common reed, reed canary grass, pondweed, parrotweed, duckweed, invasive *Elodea*, knotweed, milfoil, flowering rush, yellow flag iris, purple loosestrife, salt cedar, Japanese knotweed, and western false indigo become a dominant species in some areas.

**BARREN (BARREN ZONE)**

Within the barren cover type, this study focuses on the barren zone within a project reservoir. This is shoreline habitat surrounding reservoirs, which is characterized by having no permanent vegetation. When reservoirs are full of water, the barren zone is not present, or present only as a minor fringe around the perimeter of the lake. Plants do not generally grow in the barren area, and the areas do not provide good habitat for wildlife. They are discussed herein because barren areas do present challenges and opportunities for wildlife and can influence migration and predation. As projects are operated and reservoirs are drawn down, the land previously underwater surrounding the lake is exposed. Generally, the storage projects such as Hungry Horse, Libby, Albeni Falls, Grand Coulee, and Dworshak have a wider barren zone during drawdown than run-of-river projects.

**ISLANDS**

In the CRS study area, islands occur both in reservoirs and rivers. Individual islands or groups of islands may contain one of the cover types identified above, or may contain a mosaic of these cover types. Depending on their size, elevation, and available habitat types, islands can support a wide variety of plant and wildlife species.

In the CRS study area, there are hundreds of islands found both in reservoirs and downstream of the projects, which provide crucial habitat for wildlife species. For example, the Blalock Islands are low-elevation bedrock islands, which are part of the Umatilla National Wildlife Refuge in Lake Umatilla. The Blalock Islands are notable because they provide breeding habitat for colonial nesting waterbirds like Caspian terns, American white pelicans, and several gull species. Other islands, like Puget, Whites, and Tenasillahe Islands downriver from Bonneville Dam, cover large areas and provide a diverse array of mixed habitat types supporting numerous wildlife species and populations. Tenasillahe Island is notable because it provides complex forested wetlands and oak savannahs, which support the Endangered Species Act (ESA)-listed threatened Columbian white-tailed deer. Other islands support large breeding colonies of waterbirds, including Miller Sands Island and East Sand Island near the mouth of the Columbia River. Several thousand Caspian terns and double-crested cormorants nest at East Sand Island, along with smaller populations of Brandt's cormorant and ring-billed gulls. Several hundred American white pelicans nest at Miller Sands Island and Rice Island in the lower river.

#### ***3.6.2.2 Introduced and Invasive Species***

Non-native and invasive plants are currently damaging biological diversity and ecosystem integrity across the Columbia Basin and within the study area. Invasive plants cause displacement of native plants; reduction of habitat and forage for wildlife; changes to plant composition in sensitive areas such as wetlands; loss of sensitive species; impaired water quality; reduced soil productivity and increased erosion; and changes in the intensity and frequency of fires. Invasive plants spread through the air and water, on vehicles, animals, and humans. All lands are at risk of invasive plants. A few of the most common invasive plants in the study area are cheatgrass (*Bromus tectorum*), flowering rush (*Butomus umbellatus*), reed canary grass (*Phalaris arundinacea*), and Eurasian watermilfoil (*Myriophyllum spicatum*).

Throughout the study area, the co-lead agencies are involved with cooperative weed management efforts, invasive species prevention and eradication, and vegetation treatments. For example, on wildlife mitigation properties funded through Bonneville's F&W Program, project partners are replanting grasslands and other habitats with native species in order to outcompete non-native weeds as well as experimenting with prescriptive livestock grazing and other tools.

Populations of invasive plant species are expected to continue to occur and potentially increase throughout the study area, consistent with current trends. The alternatives proposed herein would not change or impact the co-lead agencies' ability to continue with these efforts or affect their ability to conduct invasive species management efforts at projects or participate in cooperative weed management efforts. Effects from invasive species to vegetation, wetlands, and wildlife are discussed only when alternatives are anticipated to cause a measurable change in the quantity or distribution of invasive species and their subsequent impact on the ecological function of wildlife habitat. The alternatives may impact vegetation communities and increase or expose bare ground. Where this may occur, and where weeds are a concern, impacts are discussed.

Aquatic species are of particular concern, since they spread rapidly and can quickly alter the function of an ecosystem. Quagga mussels (*Dreissena bugensis*) and zebra mussels (*Dreissena polymorpha*) are invasive, fingernail-sized mollusks that are native to fresh waters in Eurasia. They spread by drifting in water currents and attaching to watercraft. They negatively impact ecosystems in many ways causing harm to the environment, the economy, or to human health. They filter out algae that native species need for food and they attach to and incapacitate native mussels. The threat of zebra mussels at hydropower facilities relates to the species ability to quickly colonize underwater infrastructure such as screens, trash racks, and water delivery systems, which has the potential to render fish passage and protection facilities inoperable. The Columbia River Basin is the last river system free of these mussels in the United States (NWER 2015).

Strict boating inspection and widespread educational materials and training are essential to keeping these species out of the system. Idaho, Montana, Oregon, and Washington all have established rapid response plans for these mussels (Western Regional Panel on Aquatic Nuisance Species 2010; Idaho Department of Agriculture 2012; WDFW et al. 2014; Center of Lakes and Reservoirs-Portland State University et al. 2013). The states are also currently in the process of developing a cost-share agreement with the Corps, under Section 104 of the River and Harbor Act of 1958 (as amended), for development of a rapid response plan.

Additional invasive fish species are listed in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*. If these species are present in the CRS study area, they may require control measures. Species that have not yet become established but have the potential to be introduced are the Asian carp, emerald ash borer, European chafer, longhorned beetle, northern snakehead fish, and overbite clam.

#### *3.6.2.3 National Wildlife Refuges and Other Federally Managed Wildlife Lands*

Throughout the CRS study area, there are numerous national wildlife refuges and other federally managed lands for the benefit of wildlife. Of these, the Kootenai, McNary, and Umatilla National Wildlife Refuges (NWRs) and the Corps-managed Habitat Management Units (HMUs) along the lower Snake River may be impacted by one or more of the alternatives presented in this draft EIS, therefore the discussion is limited to these areas.

The Kootenai NWR near the Selkirk Mountains of northern Idaho was established as a migratory waterfowl refuge. The refuge provides habitat for over 220 bird species including bald eagle, mallard, northern pintail, and green-winged teal. Forty-five species of mammals use the refuge habitat, including moose, elk, deer, bear, and otter (USFWS 2017). This refuge contains 2,774 acres of wetlands, meadows, riparian forests, and cultivated agricultural fields, which provides habitat for over 220 bird species and 45 mammal species (USFWS 2017). The seasonal wetlands are drained in spring and summer to promote emergent vegetation for waterfowl.

There are five special wildlife management areas in the Hungry Horse Project study area: the Owen Sowerwine Natural Area, Flathead River Wildlife Habitat Protection Areas, Foys Bend Fisheries Conservation Area, and North Shore Waterfowl Production Area. These areas are mainly restored wetlands and planted riparian areas and are important bird areas that are managed to maintain or improve habitat conditions for fish and wildlife.

McNary NWR covers over 15,000 acres along the left bank of Lake Wallula from the confluence of the Columbia River with the Snake River to the mouth of the Walla Walla River, and downstream into Oregon. The refuge includes sloughs, ponds, streams, islands, forested and herbaceous wetlands, and upland shrub-steppe and cliff-talus habitats. It serves as an anchor for biodiversity in the middle Columbia Basin (Corps 2018).

The Umatilla NWR provides wildlife habitat along both shorelines of Lake Umatilla, where the refuge is composed of a multitude of different habitat types supporting a wide diversity of wildlife. The refuge includes many islands, which provide breeding/nesting/roosting habitat for colonial (mostly fish-eating) nesting birds as well as habitat supporting a variety of waterfowl species.

Within the lower Snake River Projects study area, HMUs were developed as mitigation for effects to wildlife resources during dam construction and operations. A total of 62 HMUs are scattered along the Snake River from Ice Harbor Dam to the upper extent of the Lower Granite Reservoir. There are approximately 107,382 acres of HMUs within the lower Snake River Projects study area. These HMUs include uplands, wetlands—forested and scrub-shrub, wetlands—emergent herbaceous, and islands land cover types.

There are several refuges downstream of Bonneville Dam that span and support multiple habitat types, vegetation communities, and salinity gradients. Pierce, Franz Lake, Steigerwald Lake, and Ridgefield Lake NWR are managed as the Ridgefield Wildlife Complex. This collection of refuges supports a broad mosaic of wetlands, riparian forests, sloughs, wet meadows, and meadows, all of which support a high diversity of plants and wildlife. The Julia Butler Hansen Refuge for Columbian white-tailed deer and the Lewis and Clark NWR are managed as part of the Willapa Complex and also contain a diverse array of habitats and habitat features to support fish and wildlife in the region. The Lewis and Clark NWR encompasses 20 islands and stretches over 27 miles of the Columbia River. Additional information about refuges and refuge complexes are available in Appendix F, Vegetation and Wildlife.

Where impacts are anticipated to these wildlife areas, they are discussed below under the appropriate alternative and region. If an alternative is not anticipated to result in impacts to wildlife refuges or management areas, or there are no refuges or wildlife management areas in a given region that would be affected by an alternative, no narrative is provided in the analysis under Section 3.6.3.

#### *3.6.2.4 Wildlife*

The CRS study area provides important habitat for a diversity of wildlife species. Hundreds of wildlife species use the Columbia River mainstem and tributaries for breeding, nesting, feeding, and sheltering, including amphibians, reptiles, birds, and mammals. Wildlife species common to habitat found throughout the CRS study area are briefly discussed in this section. Species were grouped into the following broad categories: birds, mammals, reptiles and amphibians, and invertebrates. The information in this section was gathered from published and unpublished reports and discussions with local professional wildlife biologists. Additional information regarding wildlife associated with the different reaches can be found in Appendix F, *Vegetation and Wildlife*.

Note that special status species are discussed in a subsection below.

**BIRDS**

The Columbia River and its tributaries provide habitat for many migrating and resident birds. The CRS study area includes several important stopover areas for migrating birds as well as many important bird areas ranging from the north shore of Flathead Lake in Montana to along the Pacific Ocean. The CRS study area is within the Pacific Flyway and a portion of the Central Flyway and thus provides crucial resting and foraging habitat for millions of migrating birds, as well as a variety of primary habitat and niche habitat for resident and breeding birds. Species associated with wetlands, riparian areas, open water, arid lands, and forests are abundant throughout the CRS study area.

In the upper basin reaches of the CRS study area such as Libby, Hungry Horse, Albeni Falls, and Dworshak, forested areas provide habitat for raptors and species such as mountain chickadee, woodpecker, bluebird, crossbill, and pine siskin. The habitats surrounding the Grand Coulee Dam, the lower Snake River Projects, and down to The Dalles provide arid, canyon, sagebrush steppe, and dry forest habitats for sage-grouse, northern harrier, cliff swallow, and horned lark. The lower reaches of the Columbia support American white pelican, tern, great blue heron, plover, and sandpiper. Bald and golden eagles nest throughout the CRS study area. Reservoirs provide feeding areas for these large birds and other raptors. They most commonly nest in large cottonwoods, snags, pine trees, or other evergreen trees or on cliffsides.

Common raptor species include goshawk, Swainson's hawk, Northern harrier, ferruginous hawk, Cooper's hawk, red-tailed hawk, merlin, osprey, American kestrel, prairie falcon, and Peregrine falcon. Barred owl, Western screech owl, flammulated owl, short-eared owl, Northern saw-whet owl, great horned owl, and burrowing owl are found in the CRS study area as well. Owls nest in or on riparian trees and upland forests, snags, hillsides, and open woodlands and hunt small birds and mammals in forested areas, open grasslands, and agricultural lands. Riparian cottonwood areas and nearby evergreen forests are also important nesting habitats for other raptors, including bald eagle, osprey, falcons, and hawks, where birds hunt and forage in wetlands, shallow-water habitats, and the deeper waters of the Columbia River for fish and other prey.

Shorebirds and waterfowl are abundant throughout the CRS study area during all seasons, but particularly during migration periods when hundreds of species can be found at important bird areas, such as the north shore of Flathead Lake and the Columbia, McNary, and Umatilla NWRs. Many large waterbirds, including tern, cormorant, and gull, prey on juvenile fish, including salmonids out-migrating to the ocean. These birds are frequently found nesting and foraging near projects in the middle and lower Columbia River, as well as in the Columbia River Estuary. Shorebirds and other waterbird species also frequent dams and mudflats surrounding reservoirs for foraging and some nesting. Shorebirds and waterbirds commonly found on mudflats include various grebes and gulls, sandpiper, plover, American coot, killdeer, common snipe, greater and lesser yellowlegs, long-billed curlew, American avocet, great blue heron, American white pelican, long-billed dowitcher, greater egret, and American bittern. Over 30 waterfowl species use open water, marshes, deltas, and riparian areas associated with the rivers and reservoirs. Waterfowl nest in marshes and adjacent riparian or upland habitats. Emergent vegetation, submerged vegetation, and shoreline habitats are also important for rearing activities and for food resources. The most numerous and diverse species of waterfowls are migrants, many of which are also year-round residents. Common species include mallard, wood duck, bufflehead, harlequin duck, pintail, American widgeon, teal, gadwall, goldeneye, grebe, scaup, American coot, common merganser, tundra and trumpeter swans, cackling goose, Barrow's goldeneye, and Canada goose. Many of the reaches support large flocks of waterfowl, and serve as major stopovers in the spring and fall for tens of thousands of birds. Some of the highest concentrations of waterfowl in the Pacific Northwest are found in the CRS study area at numerous locations. Wetland habitats, which can be rare in arid areas, provide high-quality forage and cover for overwintering waterfowl. Island habitats provide protected nesting habitats as well.

The CRS study area provides diverse habitat for passerines (also known as perching or songbirds). The upper basin reaches have mixed confer habitats which support species such as the mountain chickadee, swallow, wren, bluebird, finch, flycatcher, red-breasted nuthatch, American robin, hermit thrush, warbling vireo, red-eyed vireo, fox sparrow, pine siskin, and dark-eyed junco. Riparian areas, marshes, and islands provide habitat for warbling vireo, yellow warbler, common yellowthroat, thrush, swallow, bobolink, red-winged blackbird, marsh wren, song sparrow, white-crowned sparrow, and numerous others. Horned lark, western meadowlark, loggerhead shrike, sage thrasher, and sage sparrow are representative passerine species found in sage-steppe upland habitat. Colonies of cliff swallow and bank swallow are found throughout the CRS study area along the Columbia River and tributaries. While not classified as passerines, numerous woodpecker species have been observed in the CRS study area, including Lewis's woodpecker, hairy woodpecker, downy woodpecker, Northern flicker, pileated woodpecker, red-naped sapsucker.

Gallinaceous and Columbine birds, or ground-feeding birds, in the CRS study area include several species of grouse, wild turkey, ring-necked pheasant, Eurasian collared dove, mourning dove, Hungarian partridge, California quail, and band-tailed pigeon. In higher elevations, the ruffed grouse and blue grouse are common in riparian areas, while spruce grouse are common in coniferous forests along valley walls. Agricultural lands near rivers support ring-necked pheasant and mourning dove. Chukar, Hungarian partridge, collared dove, mourning dove, ring-necked pheasant, and California quail eat a variety of seeds, agricultural plants (e.g., wheat, oats, and corn) and insects. Pheasant and quail are found most commonly near agricultural lands and generally do not venture far into shrub-steppe areas. Chukar use a wide variety of habitats including riparian, shrublands, talus areas (accumulated rocks at the base of slopes), and uplands. The breeding and wintering range for Eurasian collared dove has increased westward in recent years as the species rapidly moves into new habitats following introduction into Florida in the 1980s.

**MAMMALS**

Common mammals found within some or all the CRS study area include coyote, fox, mule and white-tailed deer, elk, black bear, mountain goat, raccoon, beaver, rabbit, weasel, skunk, porcupine, chipmunk, squirrel, vole, shrew, bushy-tailed woodrat, kangaroo rat, deer mouse, and the house mouse. The smaller mammals can be found throughout various types of vegetation communities in the CRS study area. In higher elevations, such as near Albeni Falls, Libby, and Hungry Horse projects, less common species are snowshoe hare, marten, Canada lynx, grizzly bear, wolverine, bighorn sheep, fisher, and moose. Mule deer, white-tailed deer, and elk are the most common species managed for hunting in the CRS study area. Herds of big game species are common in all reaches and rely on the diversity of habitats to provide food and cover for their survival and successful reproduction.

Bats are found throughout the CRS study area and likely forage on insects over and near the reservoirs and rivers. Documented species of bats are Townsend's big-eared bat, pallid, fringed myotis, long-eared myotis, long-legged myotis, small-footed myotis, canyon bat, California bat, hoary bat, silver-haired bat, big-brown bat, and Yuma myotis. These bats forage on stream insects such as midges, caddisflies, and mayflies and can roost up to 2 miles from the river and reservoir in various habitat types such as forests, arid grassland, shrubs, trees, and rocky areas. Most of the bat species use a wide range of locations, including caves, mines, trees, buildings, bridges, dams, and rock crevices as roost sites. White-nose syndrome, a disease caused by a fungus that affects hibernating bats, is not currently known in the study area, but it has been detected in Washington State. White-nose syndrome is considered one of the worst wildlife diseases in modern times and has decimated populations in the eastern United States and Canada.

Aquatic mammals in the CRS study area include beaver, muskrat, river otter, and mink, whose population densities are highly variable across the CRS study area. Beaver prefer riparian habitats and marshes with willow, poplar, or other soft wood trees, near permanent water sources. Muskrat, otter, and mink use the rivers, sloughs, lakes, reservoirs and streamside habitats. The barren areas associated with storage reservoirs and rivers limit the habitat availability for these and many other species.

**AMPHIBIANS AND REPTILES**

The variety of aquatic, riparian, and upland habitats supports several species of amphibians and reptiles but in numbers notably less than in warmer regions of the United States. Most amphibian and reptile species depend on shallow-water areas, streambanks, and reservoir edges, and favor submerged or seasonal emergent vegetation. Amphibian and reptile species use these areas during portions of the year because they provide an abundance of food, cover, and water. Amphibians are present in many of the wet habitats, especially wetland and riparian habitats, and include Pacific giant salamander, tiger salamander, long-toed salamander, tree frog, Columbia spotted frog, leopard frog, Pacific chorus frog, tailed frog, Western toad, and the non-native invasive American bullfrog. Bullfrogs are predators for other amphibians and reptiles and can decimate or extirpate local native populations. Many amphibians are closely tied to wet habitats like rivers and sloughs while reptiles can be found from upland coniferous forests to the mats of emergent plant bed in river sloughs. Columbia spotted frog, a Federal ESA candidate species, and Coeur D'Alene salamander, listed as a species of special concern in Idaho and Montana, may be present within the study area. Western toad and Northern leopard frog breed in off-channel pools and forested woodlands along slow-moving rivers in Montana, Idaho, and along the shore of Lake Roosevelt from early May until late June. Tadpoles are general present form late May to early September.

Reptiles include painted turtle, garter snakes (common and western terrestrial), prairie and western rattlesnakes, bull snake, racer, gopher snake, western skink, rubber boa, short-horned lizard, sagebrush lizard, Western fence lizard, and Northern alligator lizard. Reptiles occur in a wide variety of habitats including grasslands and coniferous forests.

#### *3.6.2.5 Floodplains*

Floodplains are the low-lying, relatively flat areas adjoining water bodies that become partially or completely inundated during periods of high flow and rapid surface runoff. Floodplains are generally distinguished from adjacent uplands by a noticeable change in the ground slope. Floodplains include low-elevation areas that are regularly flooded (e.g., every two or three years, on average) and extend to areas at higher elevations that may be rarely flooded. Lower magnitude floods that occur more frequently can be important in the functioning of natural floodplains. Relatively undisturbed floodplains, or those that are restored to a more natural state, can provide a variety of benefits including natural flood and erosion control, water quality maintenance, and groundwater recharge; maintenance of biodiversity, fish and wildlife habitat, and ecosystem services; and societal benefits such as agricultural production, aesthetic values, and recreational opportunities (Federal Emergency Management Agency [FEMA] 1994).

Flood risk management focuses on reducing the effects of high-hazard, low-frequency floods. For the purpose of flood risk management, the floodplain area is defined by its probability of being inundated. The base (100-year) floodplain is the inundated area resulting from a flood with an annual exceedance probability (AEP) of 1 percent. That is, there is a 1 percent chance that the base floodplain will be inundated during any given year. The critical action (500-year) floodplain has a 0.2 percent chance of being inundated during any given year (AEP of 0.2 percent). As described in Section 3.9, *Flood Risk Management*, Columbia River Basin floodplains have been extensively modified during the last century for flood risk management (e.g., levees). These modifications substantially affected the occurrence and functioning of the natural floodplains along the river. In addition, projects supporting navigation, hydropower, and agricultural production have impacted benefits associated with relatively undisturbed floodplains. The effects of past floodplain modifications on other resource areas are discussed elsewhere in this chapter: Section 3.3.2 describes effects on sedimentation and river morphology; Section 3.4.2 describes effects on water quality; and Section 3.5.1 describes effects on fish habitats.

The existing floodplains within the Columbia River Basin occupy the open water and wetland areas shown in the figures in Section 3.6.1, *Area of Analysis*. Much of the area designated as upland in these figures occupies the natural (pre-development) floodplain, but is currently protected from flooding by levees and reservoir operations (Section 3.9.3). Because of the way uplands are defined here, portions of the areas that are designated uplands in the Section 3.6.1 figures actually may lie in the active floodplain and wetlands, although these areas are likely to be infrequently flooded.

#### *3.6.2.6 Special Status Species*

The following list of threatened, endangered, and sensitive species are species that are listed or candidates for listing under the ESA of 1973, as amended, and/or protected under the Marine Mammal Protection Act (MMPA) of 1972, as amended. The list covers species that may occur within the CRS study area or be impacted by any of the alternatives (Table 3-101). The USFWS Environmental Conservation Online System database and USFWS field office websites were accessed to determine if species should be considered given their range and habitat preferences. Appendix F, Vegetation and Wildlife, includes more information regarding migratory bird and marine mammal special status species.

Special Status Species were identified using the USFWS Environmental Conservation Online System (ECOS) database, USFWS field office websites, and previous biological opinions. Species evaluated in previous biological opinions that are outside of the influence of the CRS operations were not considered for further assessment. These include the woodland caribou, Northern Idaho ground squirrel, water howelia, Spalding’s catchfly, White Bluffs bladderpod, gray wolf, and Macfarlane’s four o’clock. The effects to these species will not change as a result of CRS. Additional terrestrial species that are were not carried forward through the assessment include the Canada lynx, pygmy rabbit, red tree vole, marbled murrelet, northern spotted owl, short-tailed albatross, Nelson’s checker mallow, and Oregon spotted frog. These species are evaluated, and CRS was determined to have “no effect” as they are spatially separated from the CRS. For more information on these species, refer to Appendix F.

**Table 3-101. Candidate, Endangered, and Threatened Species in the Vicinity of the Columbia 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 | – | – |

| 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 |

Note: C: candidate; E: endangered; T: threatened; N/A = not applicable.

## GRIZZLY BEAR

The grizzly bear is listed as threatened throughout the conterminous United States, except in the Bitterroot recovery area where it is listed as an experimental population. The current range for grizzly bear overlaps with areas in the CRSO study area in Montana near Libby and Hungry Horse Reservoirs. Habitat use by grizzly bear within the Columbia River Basin varies throughout the year and may include open-canopied upland forests, meadows, riparian and riverine areas, and shrub lands. The Northern Cascades Ecosystem (NCE) in north-central Washington and south-central British Columbia has the most at-risk population in the United States today. The grizzly bear recovery zone within the NCE encompasses 9,800 square miles, includes all of the North Cascades National Park, and most of the Mount Baker-Snoqualmie, Wenatchee, and Okanogan National Forests (Servheen 1997), and extends to the Columbia River. Despite the NCE encompassing, beyond the recovery zone, an additional 3,800 square miles across the U.S.-Canada border and providing rugged, remote habitat, the grizzly bear population in Washington is estimated to be fewer than 20 animals. The population is under review to determine a potential up-listing from threatened to endangered status. The eastern border of the NCE parallels State Route 97 and nearly reaches Chief Joseph Dam.

The Northern Continental Divide Ecosystem (NCDE) in northwestern Montana includes Glacier National Park, and the Bob Marshall Wilderness Complex, including the Flathead, Kootenai, Helena-Lewis and Clark, and Lolo National Forests, contained within 8,900 square miles. The population within this ecosystem is approximately 1,000 animals and continues to grow. This ecosystem encompasses the Hungry Horse Dam study area including the Hungry Horse Reservoir and all forks of the Flathead River.

The Cabinet-Yaak Ecosystem (CYE) is located in northern Idaho and northwest Montana and has an estimated 50 grizzly bears. The Kootenai River, with the Cabinet Mountains to the south and the Yaak River area to the north, bisects the CYE. Most of the 2,600 square miles are within the Kootenai and Panhandle National Forests (USFWS 2017a). This ecosystem encompasses Libby dam study area, northern area of Lake Pend Oreille, and the Kootenai River.

**COLUMBIAN WHITE-TAILED DEER**

The Columbia River Distinct Population Segment (DPS) of the Columbian white-tailed deer has maintained its threatened status since listing on March 11, 1967 (32 FR 4001). The Columbia River population occurs along the lower Columbia River in Oregon and Washington from Wallace Island at River Mile (RM) 50 downstream to Karlson Island at RM 32. There are four main subpopulations (Washington mainland, Tenasillahe Island, Puget Island, Wallace Island–Westport) of Columbian white-tailed deer and one minor one (Karlson Island) that are geographically separated by a main river channel or patches of unfavorable habitat. Julia Butler Hansen National Wildlife Refuge, located in the Columbia River Estuary, was established by USFWS for the recovery and maintenance of the Columbian white-tailed deer.

The islands and bottomlands within an 18-mile stretch of the lower Columbia River contain most of the Columbian white-tailed deer range. The Columbian white-tailed deer are restricted to the flatlands, which have an elevation of about 10 feet above sea level. Vegetation cover preferred by Columbian white-tailed deer includes forested communities with plant heights of at least 2 feet. Studies completed in the 1970s identified the primary plant communities used by Columbian white-tailed deer as park-forest, open canopy forest, sparse rush, and dense thistle (Suring 1974), and some subpopulations used “tidal spruce” communities (Davison 1979).

**STREAKED HORNED LARK**

The streaked horned lark was listed as threatened in October 2013. The streaked horned lark is endemic to the Pacific Northwest and is a subspecies of the wide-ranging horned lark. Streaked horned larks are small, ground-dwelling birds, approximately 6 to 8 inches in length. The combination of small size, dark brown back, and yellow on the underparts distinguishes this subspecies from other horned larks. The current range of the streaked horned lark can be divided into three regions: (1) the Puget lowlands in Washington, (2) the Washington coast and lower Columbia River islands (including dredge spoil deposition sites near the Columbia River in Portland, Oregon), and (3) the Willamette Valley in Oregon (USFWS 2018c).

Streaked horned larks require wide-open spaces with no trees and few or no shrubs. They nest in the ground in sparsely vegetated sites. They use prairies, coastal dunes, sandy beaches, and grasslands. Occupied habitat adjacent to the Columbia River from Corbett, Oregon, west is designated critical habitat.

**WESTERN YELLOW-BILLED CUCKOO**

Western yellow-billed cuckoo was listed as threatened in November 2014. While critical habitat has been proposed by the USFWS, no portion of the CRSO study area was identified for designation. However, suitable habitat for yellow-billed cuckoo occurs throughout the Columbia River Basin where large remnant stands of forested wetland habitat occurs near Flathead Lake in Montana, the Clearwater in Idaho, and along the Columbia and Snake Rivers in Washington State. The yellow-billed cuckoo breeds throughout much of the eastern and central United States, winters almost entirely in South America east of the Andes, and migrates through Central America (USFWS 2018e).

The western yellow-billed cuckoo uses wooded habitat with dense cover and water nearby, including woodlands with low, scrubby vegetation, overgrown orchards, abandoned farmland, and dense thickets along streams and marshes. In the western United States, cuckoo nests are often placed in willows along streams and rivers, with nearby cottonwoods serving as foraging sites (USFWS 2018e).

**UTE LADIES'-TRESSES**

Ute ladies'-tresses was listed as threatened in January 1992. Part of its range includes a small area adjacent to the Columbia River in Chelan, Okanogan, and Douglas Counties, north of Wenatchee, Washington. It is a rare perennial, terrestrial orchid with stems 8 to 20 inches tall. The orchid occurs along riparian edges, gravel bars, old oxbows, and high flow channels, and moist wet meadows along perennial streams (USFWS 2018g).

Potentially suitable habitat occurs on stabilized gravel bars and/or shoreline areas along the Columbia River that are moist throughout the growing season and inundated early into the growing season. While the species has a wide range across the western United States, within the action area, the plan is currently documented in Washington State, occurring along the Rocky Reach Reservoir on gravel bars adjacent to the Columbia River in Chelan County, Washington (Fertig et al. 2005).

Natural flooding cycles are important for creating new alluvial habitat and for reducing cover of competing plant species for Ute ladies'-tresses throughout their range, including along the Columbia River (Fertig et al. 2005). While discharge from Chief Joseph Dam influences downstream flows, the water surface elevation in Rocky Reach reservoir is primarily controlled by the operation of Rocky Reach Dam, which is owned and managed by Chelan County Public Utility District.

**SOUTHERN RESIDENT KILLER WHALE DISTINCT POPULATION SEGMENT**

The Southern Resident killer whale DPS is a single population totaling 78 individuals as of 2016 (Centre for Whale Research 2016). The population ranges from central California to southeast Alaska. During the period from July to September, the DPS inhabits the Salish Sea and the waters near the entrance of the Strait of Juan de Fuca. Winter habitat frequently includes the Washington coast and less often the coastal waters of central California by two of the three pods (K and L) (NMFS 2014). There is no critical habitat designated within the CRSO study area; however, NMFS has proposed critical habitat for the Pacific Ocean marine water along the West Coast between Cape Flattery, Washington, and Point Sur, California, as for the Southern Resident killer whale DPS (84 FR 49214).

The National Marine Fisheries Service (NMFS) has analyzed Chinook salmon stocks based on their estimated importance to the whales and found that the most crucial stocks are those returning to the Fraser River in British Columbia, other rivers draining into Puget Sound and the Salish Sea, and the Columbia, Snake, Klamath, and Sacramento Rivers. The NMFS analysis showed that Puget Sound Chinook salmon stocks are one of the most important salmon stocks for Southern Resident killer whale because the whales have access to them for a greater part of the year than fish from the Columbia, Snake, and Fraser Rivers. Other Chinook salmon stocks from the Columbia River Basin vary in overall importance for the diet of Southern Resident killer whale. For example, Snake River spring-summer Chinook salmon are mainly available to Southern Resident killer whale when the fish gather off the mouth of the Columbia River, whereas Snake River fall Chinook remain closer to the coast and would be available for a longer period before migrating upriver in the fall (NMFS 2014b, 2018; NMFS and WDFW 2018). At times or locations of low Chinook salmon abundance, whales also select other species such as chum salmon, smaller salmonids, or other non-salmonid prey (herring or rockfish).

**STELLER SEA LION**

The Eastern DPS of the Steller sea lion occurs along the West Coast between Washington and California. The Steller sea lion is the largest member of the family Otariidae, the “eared seals.” Steller sea lions are opportunistic predators, foraging and feeding near shore and in open waters on a wide variety of fishes and cephalopods (NMFS 2014a). The Steller sea lion was previously listed under the ESA and the Eastern DPS was delisted in 2014 because it had met its recovery goals (NMFS 2013). In 2010, the NMFS status assessment estimated the population included approximately 70,000 individuals and had maintained a positive growth rate for several years; the Western DPS (Steller sea lions born west of Cape Suckling, Alaska, at 144 degrees west longitude) is still listed as endangered under the ESA (NMFS 2013). The Eastern DPS is still protected under the Marine Mammal Protection Act (MMPA) in all areas where individuals occur.

In the Columbia River, Steller sea lion use the South Jetty on the Oregon shore at the mouth of the Columbia River as a haul out area, but no reproductive activity has been documented there; the Steller sea lion has not been observed using the North Jetty on the Washington shore as a haul out area. The closest breeding rookery to the Columbia River is on the southern Oregon coast at Rogue Reef. Use of the South Jetty by Steller sea lion occurs year round but is heaviest from April through October when as many as 200 to 300 individuals can be present. Steller sea lions typically forage at river mouths and coastal nearshore areas; however, some individuals are regularly observed foraging on white sturgeon and migrating adult salmon as far upstream as Bonneville Dam on the Columbia River and Willamette Falls on the Willamette River. Between 2002 and 2017, the number of Steller sea lions foraging at Bonneville dam has increased from 0 individuals in 2002 to a high of approximately 69 in 2015 (Tidwell et al. 2018).

**CALIFORNIA SEA LION**

Like Steller sea lion, the California sea lion is an eared seal native to the West Coast of North America where they live in coastal waters and on beaches, docks, buoys, and jetties. The California sea lion is distributed from the southern tip of Baja California to southeast Alaska, and they are protected under the MMPA in all areas. The California sea lion breeds in rookeries in southern California and Baja California and individuals move north after the breeding season to forage in productive nearshore areas along the Pacific coast. In 2007, the minimum population for California sea lion was estimated at approximately 150,000 individuals and the population has experienced a positive growth rate since the 1970s (NMFS 2015). The primary diet of California sea lion is a variety of fish and shellfish, including salmon, steelhead, Pacific whiting, herring, mackerel, eulachon, lamprey, codfish, walleye Pollock, spiny dogfish, and squid.

In the Columbia River, California sea lion can be found on the South Jetty, piers, and docks in Astoria, Oregon. Since the mid-1980s, increasing numbers of California sea lion have been observed foraging on white sturgeon and migrating adult salmon at Bonneville Dam, 146 miles from the mouth of the river. Scat samples collected in coastal waters and in the Columbia River estuary indicate that salmon comprise 10 to 30 percent of the animals' diet (ODFW 2017). Between 2002 and 2017, the number of individual California sea lions observed foraging at Bonneville dam has increased from 30 animals in 2002 to a high of 195 in 2015 (Tidwell et al. 2018). Foraging has also been observed at The Dalles Dam.

### 3.6.3 Environmental Consequences

#### *3.6.3.1 Methods and Assumptions*

**METHODS**

Effects to vegetation, wetlands, and wildlife were quantitatively and qualitatively assessed using the best available science and technical methodologies that were accessible for the analysis area. H&H modeling, as described in Section 3.2, was used to estimate water surface elevations and identify the spatial patterns of inundation across the analysis area. The H&H output included seasonal water-level dynamics at discrete locations and inundated area polygons for peak annual water-surface profiles. Potential changes to water surface elevations and the timing and frequency of changes in the reservoir and downstream riverine portions of the Flathead, Kootenai, Pend Oreille, Snake, Clearwater, and Columbia Rivers were used to identify potential effects to habitat, vegetation, floodplains, and wildlife. For the action alternatives, results from the H&H modeling were evaluated on annual, seasonal, monthly, and where relevant, more frequent time-scales to assess change relative to the No Action Alternative and current conditions of the affected environment. H&H model index points were used to assess changes to water surface elevations and effects at potentially sensitive wildlife sites.

Different habitat zones were identified in each reach using USFWS NWI maps, NWHI data, best professional judgment, referenced and local knowledge of the analysis area, and aerial photography. Where possible, the approximate elevations where one habitat type transitioned to another habitat type (for example, the elevation where forested and scrub-shrub wetlands transition to emergent herbaceous wetlands) were identified to assess potential effects. These approximate elevations were calculated using GIS methods in which the NWHI land cover and NWI data layers were overlaid on a 1-meter digital elevation model relief map.

In general, the transition zones from emergent herbaceous wetlands to forested and scrub-shrub wetlands, and forested and scrub-shrub wetlands to upland habitats are dependent upon water surface elevations during the growing season (Figure 3-148). Changes to water surface elevations during the growing season have the potential to impact wildlife phenology and fecundity. A decrease in water surface elevation leads to drier conditions, habitat transition, or plant composition shifts to those more tolerant of dry or drought conditions. An increase in water surface elevation leads to wetter conditions, habitat transition, or plant composition shifts to those more tolerant of wet or inundation conditions.

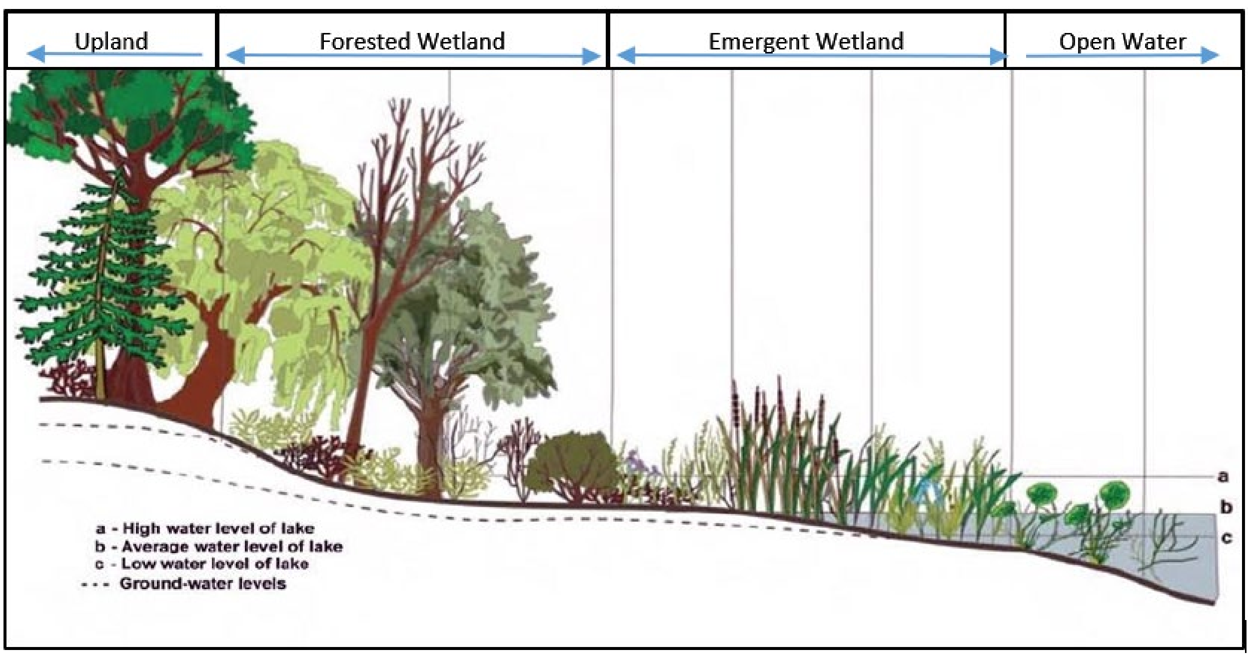



**Figure 3-148. Diagram of Upland and Wetland Transition Zones Typical of Proximity to Water Surface Elevations**

The effects of the alternatives on flood risks to property, structures, and human safety are evaluated in Section 3.9.4. The potential effects of the alternatives on the natural benefits provided by relatively undisturbed or restored floodplains are evaluated in this section. These benefits, described in Section 3.6.2.1, can be affected by changes in the frequency, timing, duration, and inundation area of flooding. The potential effects of the alternatives on the frequency and inundation area of flooding were evaluated by examining the change in flood elevation for a range of flood frequencies, from regularly occurring floods with an AEP of 50 percent (i.e., the flood elevation that occurs once every 2 years, on average) to the base flood with an AEP of 1 percent (the flood elevation with a 1 percent chance of being exceeded in any given year). If an alternative is predicted to cause a minimal change in flood elevations over this range of flood frequencies (AEP from 50 to 1 percent) for a given reach, it is indicative of the probability of inundation remaining unchanged from current conditions for the floodplain adjoining the reach; therefore, the benefits provided by the floodplain would be unchanged from the No Action Alternative. Tables of flood elevation changes for AEP values from 50 to 1 percent were provided by the H&H modeling team. Table 5-6 in Appendix B, *H&H*, shows results for the lower Columbia River below Bonneville Dam. Changes in flood elevations for floods occurring less frequently than the base flood (i.e., the critical action flood) were not evaluated due to uncertainties in the H&H simulation results for floods more rare than the base flood.

In terms of describing severity of effects, the descriptors defined in Section 3.1 are used to describe the anticipated magnitude of effect (No Effect, Negligible Effect, Minor Effect, Moderate Effect, and Major Effect) based on effect level described in Chapter 2.

In addition to the effects of changes in flood frequency and inundation area, the potential effects from changes in the timing and duration of flooding on vegetation, wetlands, and wildlife are discussed below. The potential effects on fish from changes in the timing and duration of flooding are discussed in Section 3.5.2.

**ASSUMPTIONS**

For all alternatives, except MO3, the analysis assumes that all ongoing, scheduled, and routine maintenance activities for the Federal infrastructure and all structural features, including those recently constructed or reasonably foreseeable to be constructed, are included and would be implemented as planned prior to September 30, 2016. For MO3, dam breaching would preclude the need for maintenance at the lower Snake River dams.

For structural changes at dams under MO1, MO2, and MO4, the construction and modification of existing structures would have relatively minor effects on existing habitats and wildlife populations. Typical construction-related effects would include, but are not limited to, temporary and short-term increases in noise, clearing or grading vegetation, erosion control, fish salvage and removal prior to commencing in-water work, and work-area isolation. These actions could result in a temporary displacement of wildlife from preferred or suitable habitat or changes in behavior if animals are near a project during construction. Where new structures are constructed, it is assumed that efforts would be made to avoid effects to wildlife habitat, and where habitat effects could not be avoided, efforts would be made to minimize and possibly mitigate potential effects to habitat and wildlife populations by implementing best management practices (BMPs) to minimize potentially deleterious effects. It is further assumed that construction activities would be detailed and designed at a future date and individual construction actions would undergo additional analysis, if needed when the effects are different from or exceed those anticipated herein. For structural changes under MO3 (e.g., dam breaching), it is assumed there would be major effects on existing habitats and wildlife populations.

BMPs for construction-related activities typically include taking measures to minimize dust, conducting plant and wildlife surveys prior to construction, working outside of the migratory bird nesting times, minimizing ground disturbance or limiting it to areas already disturbed, managing for surface water runoff, and having appropriate containment for fuels and other materials, etc.

Several programs are in place in the lower Columbia River to manage or dissuade pinniped and avian predation on salmonids. All alternatives assume that existing and ongoing predator control programs and other project operations would continue. These plans include the Inland Avian Management Plan (Corps 2018), The Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary (USFWS 2005), and the Double-crested Cormorant Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Inlet (Corps 2015).

Throughout the study area, USFWS, ODFW, Montana Fish, Wildlife, and Parks (MFWP), and Washington Department of Fish and Wildlife (WDFW), and other tribal and governmental entities manage wetland habitats and other wildlife habitat areas to support fish and wildlife. Through its Fish and Wildlife (F&W) Program, Bonneville has implemented wildlife habitat projects to address the impact of the development of the CRS, many of which were permanently acquired for wildlife habitat and provide important benefits for fish. Bonneville also provides operations and maintenance funding for these projects. The alternatives assume that the wildlife area managers would continue to implement management activities consistent with management area and refuge goals and agency policies for the benefit of fish and wildlife.

In the lower Columbia River, below Bonneville Dam, much of the historical floodplain has been levied to protect communities from flooding. Vegetation on levees is managed for structural integrity, limiting potential habitat development immediately adjacent to the river. Routine operations and levee maintenance actions would continue under all alternatives in patterns similar to current practices. In areas where levees are not regularly maintained, some erosion or degradation is evident and these areas would continue degrading consistent with current trends.

Both the Corps and Reclamation engage in cooperative weed management agreements to treat weeds and prevent infestations of invasive species, including aquatic invasive species, throughout the study area. For example, the Corps currently manages flowering rush (*Butomus umbellatus*) and other aquatic invasive species in the McNary Reservoir on submerged Federal lands through the aquatic portion of the Walla Walla District Integrated Pest Management

Program (Corps 2019, NMFS 2019, USFWS 2019). Bonneville also provides funding to decrease the spread of non-native species through its F&W Program, such as weed control actions of wildlife mitigation properties and the removal of non-native fish species that depredate on native fish. Other similar management efforts, where applied, are anticipated to reduce the spread and establishment of invasive species throughout the study area. Invasive species management is expected to continue under all alternatives. Where no management efforts are implemented, invasive plant species are expected to persist and may spread to new areas. In terms of non-native wildlife species in the analysis area, none of the alternatives propose changes in operations that would lead to changes in populations or provide advantages to non-native wildlife over native wildlife. Therefore, they are not discussed further. Efforts currently in place to detect quagga (*Dreissena rostriformis bugensis*) and zebra mussels (*D. polymorpha*) to prevent their spread into the study area would continue and there are no measures that would impact their implementation.

Throughout the study area, cottonwood (*Populus trichocarpa*) galleries (areas with highly fertile soils and water availability) and recruitment are an important habitat feature for wildlife and floodplain development. Cottonwood is a pioneer species adapted to colonize areas disturbed by floodwaters. Cottonwood seed dispersal occurs during high flows as seeds are deposited in the floodplain or above bankfull. Altered flows that do not access floodplains affect the recruitment and survival of saplings and can lead to cottonwood galleries consisting of old, mature trees that eventually die off with no new recruitment. Changes in water elevations and flows influence successful cottonwood germination and establishment. Increasingly dry conditions result in poor germination and reduced survival of cottonwood saplings if soil conditions do not retain sufficient moisture for seed germination in the spring. Subsequent high flows later in the summer or after seed dispersal and before saplings can establish strong root masses can uproot saplings. Winter conditions also influence survival of saplings and the regeneration of cottonwood forests. Ice formation in shallow-water areas, or along reservoir shorelines, can destroy sapling recruitment when water surface levels fluctuate. As water levels decrease, ice moves with the water. As pool elevations increase, ice moving along the shoreline or in shallow-water areas can scour the banks and pull entire generations of saplings out from the shoreline. This can effectively reduce the long-term regeneration of cottonwood galleries when aging forests are lost through natural succession. These relationships between operations and cottonwoods occur to some extent throughout the study area and are analyzed below where effects are particularly important.

When the CRS dams were built and the reservoirs behind them filled, they inundated about 308,996 acres, much of it important fish and wildlife habitat. To calculate the area affected by CRS development in each Region—dam construction and inundation by the reservoirs behind them—Bonneville relied on either the amounts agreed upon in negotiated mitigation agreements with state and tribal entities or the loss assessments prepared by Federal, state, and tribal wildlife managers. To date, Bonneville has implemented wildlife habitat projects on over 689,000 acres to address the impact of the development of the FCRPS, which includes the CRS, many of which were permanently acquired for wildlife habitat. Bonneville also provides operations and maintenance funding for these projects. The loss assessments relating to dam construction and inundation considered all habitat losses up to and including full reservoir pool levels. As such, mitigation for those losses can also serve to address the effects of reservoir operations on wildlife habitat, to the extent that such operational impacts occur below full pool level. These habitats would not change from current conditions in response to continued implementation of the No Action Alternative.[1]

#### *3.6.3.2 No Action Alternative*

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

Vegetation communities adjacent to the study area in Region A are dominated by upland habitat types consisting of agricultural and pasture lands, eastside (interior) grasslands, eastside (interior) mixed conifer forest, and eastside (interior) grasslands. The next most abundant habitat type, besides open water, is freshwater forested and scrub-shrub wetlands and freshwater emergent herbaceous wetlands. Wetlands are located below Libby Dam along the Kootenai River at river mile (RM) 131 through 136, 143 through 144, 184 through 190, and 216 through 219. There are extensive wetlands from Hungry Horse Dam downstream to Flathead Lake, between approximately RM 111 and 140 along the Flathead River. Wetlands within the Albeni Falls Dam study area are located on the Clark Fork River at RM 4 through 8 and 73 through 86.

Throughout Region A, the acreages for the various habitat types would remain relatively unchanged from current conditions (except as described below for riparian and cottonwood habitats below Libby). Wetland habitats would not change under the No Action Alternative because the water surface elevations that influence these habitats would be consistent with current conditions. Operations that benefit wetland habitats by maintaining certain elevations around the reservoirs and downstream would not change under the No Action Alternative. Areas throughout Region A that are recovering from historical operations would continue to recover and areas that are degrading from ongoing operations would continue to degrade if additional mitigation is not implemented.

Factors potentially altering streambank conditions, such as high flows, bankfull flows in the spring, or low-water conditions, would continue under the No Action Alternative. Existing streambank conditions, such as erosion and bank sloughing, influenced by water releases from the Federal projects would continue to occur along the Kootenai River from operations at Libby Dam. Shoreline erosion in Bonner's Ferry, Idaho, caused by frozen banks suddenly drawn down due to reduced flows, would continue to reduce wildlife habitat. The exception is the muddy eastern and northern shoreline of Lake Pend Oreille, where soils are highly erodible and fluctuating water levels from reservoir operations, boat wakes, and wind are expected to 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).

collapse. It is expected that management activities would be implemented to address localized areas of erosion where they pose a risk to public safety.

Operations at all three facilities expose a wide barren zone around the reservoirs during refill and drawdown. For wildlife, the barren zone represents an area that smaller wildlife species, such as rodents or snakes, must navigate to reach water in the reservoir. Crossing wide barren zones with no cover poses a risk of predation for prey species, which is a detriment to them, while conversely providing a benefit to predators (Huokuna et al. 2017). The barren zone width at each facility varies, but the effects on wildlife are similar in terms of predation and would continue unchanged under the No Action Alternative.

In Region A, Bonneville addressed construction and inundation mitigation for Libby and Hungry Horse Dam wildlife using a comprehensive long-term agreement. Under the 1989 Montana Wildlife Mitigation Trust Agreement (Montana Fish, Wildlife, and Parks 2013), Montana has protected or enhanced 272,104 acres (Montana Fish, Wildlife, and Parks 2019) (the Council's program called for a total of 55,837 acres of wildlife mitigation for Libby and Hungry Horse Dams split between 29,171 acres of enhancement and 26,666 acres of protection; NPCC 1987; Montana Fish, Wildlife, and Parks 2009). In the 2018 Albeni Falls Dam Wildlife Mitigation Agreement, Bonneville and the State of Idaho established that 14,087 acres had already been mitigated through the efforts of the state, the Kalispel Tribe of Indians, Kootenai Tribe of Idaho, and Coeur d'Alene Tribe (6,617 acres were impacted as a result of the construction and inundation of Albeni Falls Dam; Northern Idaho MOA 2018). In addition, Bonneville agreed to fund the State of Idaho to protect and enhance 1,279 acres of wetland habitat at the Clark Fork Delta and an additional 99 acres at the Priest River Delta to address the upriver effects of Albeni Falls operations. This is in addition to the 624 acres of wetland protected and enhanced on the Clark Fork Delta by IDFG, which was funded by Bonneville through a letter agreement in 2012.

From May 15 through September 30, operations at Libby Dam maintain higher flows (at or above 6 kcfs) to inundate the channel during the most biologically productive time of the year and exhibit a gradual decline over the summer. While operations at this location are primarily fish focused, wildlife habitats and wildlife populations would continue to benefit from increased water surface in the reservoir and water availability downstream, particularly during the summer months when temperatures are high and water levels inundate wetland habitats. The small wetland fringe in areas where the reservoir converges with small tributaries would continue to be inundated and benefit from operations.

At Libby Dam and downstream along the Kootenai River, because high winter releases scour seedlings, some riparian cottonwood communities could continue to decline in some locations due to altered hydrological conditions.

Through the F&W Program, Bonneville has funded the Kootenai Tribe of Idaho (KTOI) to manage and implement large-scale habitat restoration measures within the Kootenai River. These habitat restoration actions have increased active floodplain and worked to restore riparian forest habitat, including efforts to restore black cottonwood galleries. The 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. The KTOI have been implementing re-planting efforts below Libby Dam within the Idaho portion of the Kootenai River. The Kalispel Tribe has been planting black cottonwoods in Washington and Idaho above and below Albeni Falls Dam, both within floodplain areas and along the Pend Oreille River. IDFG, in their work to restore portions of the Clark Fork Delta, have been conducting revegetation efforts with native black cottonwoods. Mitigation actions like these would continue under the No Action Alternative.

Under the No Action Alternative, cottonwood seed deposition occurs after high flows in June and July moisten the riverbanks, and seeds are dispersed from parent trees in late summer. Winter flows can inundate and scour riverbanks, destroying tree and shrub saplings like cottonwoods and willows (*Salix* spp.) that have not yet developed sufficient root structures to withstand high winter flows or the spring freshet.

The Kootenai Wildlife Refuge contains 2,774 acres of wetlands, meadows, riparian forests, and cultivated agricultural fields, which provide habitat for over 220 bird species and 45 mammal species. The seasonal wetlands are drained in spring and summer to promote emergent vegetation for waterfowl food sources. Current operations of Libby Dam adversely affect wetland management capability, reducing availability of forested and scrub-shrub and emergent herbaceous wetlands (USFWS 2015).

The size and depth of Lake Pend Oreille (approximately 94,600 acres and maximum depth of 1,237 feet) would remain unchanged under the No Action Alternative and the estimated ordinary high water elevation in the summer and fall (2,062.5 feet and 2,051 feet NGVD29, respectively) would remain unchanged throughout the year.

Consistent with current management practices, the Corps would continue to lease approximately 4,000 acres of project lands in the Albeni Falls Dam study area to the State of Idaho for wildlife management. The Pend Oreille Wildlife Management Area (WMA) would be inundated for 4 to 5 months each year, with less than 25 percent of the area above the high-water line. Habitat in the WMAs range from mudflats exposed during reservoir drawdown in the winter to submerged lands with rooted aquatic plants and forested uplands. During the summer months under the No Action Alternative, most of the Pend Oreille WMA is emergent marsh habitat and with an average water depth of 2 to 4 feet surrounded by a narrow zone of sedges, cottonwoods, and willows. Conifers occur further inland.

Amphibians such as the western toad (*Bufo boreas*) and northern leopard frog (*Rana pipiens*) would continue to breed in off-channel pools and forested woodlands along slow-moving rivers in Montana and Idaho from early May until late June. Tadpoles are generally present from late May to early September.

Western grebe (*Aechmophorus occidentalis*) is abundant on portions of the Pend Oreille WMA, particularly in Denton Slough where one of only a few northern Idaho nesting colonies occurs. Nesting occurs from about May through September. Denton Slough is a shallow bay with a large quantity of submerged plants. These plants are used by western grebe to construct their nests, which are composed of piles of floating plant material that are typically hidden among, and may be anchored to, emergent or floating plants (Idaho Department of Fish and Game [IDFG] 1999).

The Canada goose (*Branta canadensis*) ground nests near the Priest Lake portion of the WMA along the shore and on islands (IDFG 1999). Other common nesters include mallard (*Anas platyrhynchos*); American widgeon (*Mareca americana*); gadwall (*M. strepera*); northern shoveler (*Spatula clypeata*); ring-necked duck (*Aythya collaris*); and green-winged, blue-winged, and cinnamon teal (*Anas crecca, Spatula discors,* and *S. cyanoptera*, respectively) (IDFG 1999).

In regard to potential effects in Canada, the effects on vegetation and wildlife resources and their habitats under the No Action Alternative are expected to be similar to the effects described for the United States portion of Region A.

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

Vegetation communities in Region B are primarily dominated by upland habitats. Upland habitats near the Chief Joseph Dam trend toward agricultural and pasture lands, with some shrub-steppe habitat, while upland habitats near the Grand Coulee Dam are primarily dominated by agricultural and pasture land, ponderosa pine (*Pinus ponderosa*) forests and woodlands, and shrub-steppe habitat. The next most common habitat type in Region B, besides open water, is forested and scrub-shrub wetlands. Emergent herbaceous wetlands, while sparse throughout the region, occur in isolated pockets along the rivers and lake shorelines. Uplands occur above the forested and scrub-shrub wetland habitat in both zones. There are approximately 1,600 acres of urban and mixed-use environment throughout Reach B.

Operations at Grand Coulee expose a wide barren zone around the Lake Roosevelt during refill and drawdown. For wildlife, the barren zone represents an area that smaller wildlife species, such as rodents or snakes, must navigate to reach water in the reservoir. Crossing wide barren zones with no cover poses a risk of predation for prey species, which is a detriment to them, while conversely providing a benefit to predators. The effects on wildlife are similar in terms of predation and would continue unchanged under the No Action Alternative.

Approximately 1,426 acres of forested and scrub-shrub wetlands are located within Region B. These wetlands are composed mainly of cottonwoods and willows.

Habitat types in Region B would not shift or transition to other habitat types, and the spatial extent of existing habitats would not increase or decrease as a function of the No Action Alternative. Water surface elevations, which influence wetland habitats throughout the study area, would continue consistent with current operations and patterns of inundation would continue to support these habitats following expected patterns of seasonal and annual fluctuation. Island habitats and barren areas surrounding the reservoirs would also continue to be present in amounts similar to current conditions. Wildlife use of these habitats would not change in response to implementing operational or structural measures associated with the No Action Alternative.

In this region, project partners like WDFW, Spokane Tribe of Indians (STOI), and Confederated Tribes of the Colville Reservation (CTCR) manage wildlife mitigation properties funded through the Bonneville F&W Program for wildlife mitigation. Under a 2008 agreement between Bonneville and CTCR, CTCR acquired almost 4,000 acres, which are part of the Hellsgate Game Reserve. In addition, CTCR has completed extensive habitat restoration and maintenance actions, such as invasive species and noxious weed control measures and fencing modifications to benefit reintroduced pronghorn antelope. Similar mitigation actions would continue to be implemented in Region B under the No Action Alternative.

Streambank conditions, such as erosion and bank sloughing, and vegetation along the Columbia River are influenced by water releases from Chief Joseph Dam and Grand Coulee Dam. Under the No Action Alternative, conditions affecting shorelines are expected to continue and factors influencing these, such as high flows, or bankfull flows in the spring, would continue consistent with current conditions. Furthermore, areas recovering from historical operations are expected to continue to recover, and areas that generally transition from open water directly to upland, due to the non-existence of established wetland habitats, will remain the same.

The overall wildlife values at Lake Roosevelt are limited because of the lake's storage function and substantial seasonal drawdowns, which adversely affect shorelines and the development of wildlife habitat. Habitats important to wildlife in Region B are generally confined to tributary stream reaches, embayments and backwaters, and islands; conditions are much less favorable on the main reservoir where steep, eroding banks are prevalent. Islands are important in part because only 28 remain of the 114 identified in a pre-construction assessment of the Columbia River in Region B. In general, riparian and wetland habitats exist only as small, isolated habitats around Rufus Woods Lake and Lake Roosevelt.

Winter conditions that influence predator-prey relationships in areas such as Lake Roosevelt, Lake Koocanusa, and Flathead Lake would continue. Shallow-water coves and embayments frequently freeze completely in the winter.

Both mountain lion (*Puma concolor)* and wolf (*Canis lupus*) are known to hunt or pursue prey species such as bighorn sheep (*Ovis canadensis*) and deer (*Odocoileus hemionus*) into barren zones or onto the ice in the winter. The mountain lion is more successful in its capture and kill rates when the water levels are lower in the winter or the reservoir does not refill completely before lake conditions freeze. Under these conditions, mountain lion pursue ungulates such as the bighorn sheep into the barren zone where the surface is predominantly soil instead of rock. When ungulates (i.e., elk, bighorn sheep, deer) are pushed into areas with soft sediments, they have difficulty escaping. The wolf, however, is more successful in its capture and kill rate when the water levels are higher during the winter and areas of the reservoir freeze over. Under these conditions, the wolf hunts and pursues deer and elk (*Cervus canadensis*) onto the ice where the wolf has better traction over snow and ice. Amphibians such as the western toad (*Bufo boreas*) and northern leopard frog (*Rana pipiens*) would continue to breed in off-channel pools and along the fringes of Lake Roosevelt and slow-moving sections of the Columbia River from early May until late June. Tadpoles are generally present from late May to early September.

In regard to potential effects in Canada, the effects on vegetation and wildlife resources and their habitats under the No Action Alternative are expected to be similar to the effects described for the United States portion of Region B.

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

Vegetation communities adjacent to and downstream of the Dworshak Dam are dominated by upland habitat types, including eastside interior shrublands, eastside interior mixed conifer forest, ponderosa pine and eastside white oak forest woodlands. At Dworshak, emergent herbaceous wetlands are present generally at the highest water elevation, approximately 1,600 feet, at the confluences of tributaries. Downstream of Dworshak on the Clearwater River, emergent herbaceous and forested and scrub-shrub wetlands occur within 5 feet of water surface elevation.

Dworshak's 80-foot barren zone is caused by the fluctuations of the reservoir between maximum and minimum operating pool. Since the late 1990s, the reservoir has been drawn down to 80 feet annually between July and October to improve passage and survival of endangered salmon in the Clearwater and Snake Rivers. Dworshak Reservoir does not fill until the end of June. During most of the year, large mud flats, sandy banks, and rocky slopes are visible. This has affected the elk populations during the winter months when ice freezes along the reservoir. When ice is present, elk may cross the reservoir to reach their south-facing winter range on the northern end of the reservoir. Migration across the ice occurs frequently when ice and snow conditions permit. In winters when snow accumulates on thin ice, elk and deer may fall through the ice and mortality may occur. Although mortality rates are highly variable, in some years, this can be a major source of mortality.

Wetlands along the Clearwater River are located in areas where sediment accretes at the confluence of the river with its tributaries. Hog Island, located at approximately RM 9, is a large island that includes emergent herbaceous wetlands.

The four lower Snake River projects are primarily dominated by the upland habitat types of agricultural and pasture lands and shrub steppe habitat. There are forested and scrub-shrub wetlands at Lower Granite Reservoir (Reach 9); however, most of the wetlands found at the lower Snake River projects are emergent herbaceous wetlands. There are large wetland areas located at Silcott Island (RM 131), within Lower Granite Reservoir at RM 80, and in Little Goose Reservoir at RM 58 and Lower Monumental Reservoir at RM 17. Wetlands occur approximately 3 feet from maximum operating pool elevation within the lower Snake River projects.

Habitat types in Region C would not shift or transition to other habitat types, and the spatial extent of existing habitats would not increase or decrease as a function of the No Action

Alternative. Water surface elevations, which influence wetland habitats throughout the study area, would continue consistent with current operations and patterns of inundation would continue to support these habitats following expected patterns of seasonal and annual fluctuation. Island habitats and barren areas surrounding the reservoirs would also continue to be present in similar amounts to current conditions. Wildlife use of these habitats would not change in response to implementing operational or structural measures associated with the No Action Alternative.

Streambank conditions, such as erosion and bank sloughing, and vegetation along the Clearwater, Snake, and Columbia Rivers in Region C, are influenced by water releases from Dworshak Dam, Hells Canyon Complex, and the four projects on the lower Snake (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite). Under the No Action Alternative, shoreline conditions would continue and factors influencing these, such as high flows, or bankfull flows in the spring, would continue under the No Action Alternative consistent with current conditions. Furthermore, areas recovering from historical operations would continue to recover.

The Dworshak Dam lands would continue to be managed for elk populations, wildlife habitat, and recreational use.

The 1992 Dworshak wildlife mitigation agreement with the State of Idaho, Nez Perce Tribe, and Bonneville, frequently referred to as the “Dworshak Settlement,” mitigated the impacts to wildlife from developing that dam estimated at 16,970 acres. To determine acreage protected, Bonneville relied on the Dworshak Wildlife Agreement reports from the Nez Perce Tribe. The Tribe’s 2018 annual report indicates it has purchased 7,576 acres and still has over $9.5 million remaining in its mitigation fund established under the agreement (Nez Perce Tribe 2018). The State of Idaho also has a $3 million fund provided by Bonneville to manage the 60,000-acre Peter T. Johnson Unit of the Craig Mountain Wildlife Management Area (formerly known as Craig Mountain), which Bonneville purchased and transferred to Idaho (IDFG 2014). All told, Bonneville has funded approximately 67,576 acres of mitigation for Dworshak Dam. Many of these mitigation sites are located outside of the study area.

Most of the approximate 147 miles of shoreline along the lower Snake River are managed by the Corps as mitigation areas as part of the Lower Snake River Compensatory Mitigation Plan (Corps 1975, 1996). These areas are managed to provide wildlife habitat and recreation areas. Under the No Action Alternative, the wildlife would continue to utilize the habitat types. These species include mule deer, fox, raccoons, bobcat, turkey, and various songbirds as well as otter, beaver, muskrat, and various ducks.

In addition to these areas, Bonneville secured another 61,210 acres of wildlife mitigation through habitat protection and enhancement projects implemented by the Nez Perce Tribe and Burns Paiute Tribe. For example, the Nez Perce Tribe received funding through Bonneville’s F&W Program to acquire the 16,286-acre Precious Lands project near Joseph, Oregon, outside the study area.

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

Habitats in Reach D transition from dry, Columbia River Plateau habitat types to wet forests of the Cascade Range and Oregon Coast Range. Upland habitat adjacent to John Day Dam and The Dalles study areas largely consists of shrub-steppe vegetation, mixed grasslands, and agricultural areas farmed for dryland wheat, alfalfa, barley, and vineyards. The distribution and spatial extent (overall acreage) of uplands managed by the Corps would not change under the No Action Alternative. Where upland habitats transition abruptly to the river's edge and no riparian habitat exists, there are few areas where habitat is exposed for prolonged periods of time and shoreline habitat is predominantly bedrock, sand, gravel, and silts with limited or no vegetation. Within the McNary Reservoir, there are extensive wetlands within the McNary Wildlife Area at Burbank Slough (RM 319 to 324) and mudflats at the confluence of the Walla Walla River (RM 313 to 315). The Yakima Delta contains some cottonwood forest habitat (RM 333 to 335).

Within the McNary Reservoir, Crescent Island (RM 316) was managed (fence and willow plantings) to discourage tern nesting, and monitoring of the Island would continue under the No Action Alternative (Corps 2018). The acreage of available habitat for avian predators is dependent on water surface elevation. Under the No Action Alternative, there is approximately 0.25 acre of suitable nesting habitat on Badger Island, depending on river flows, and the island supported 60 breeding pairs of Caspian terns in 2012 (Bird Research Northwest 2013). Wildlife use of these habitats would not change due to operational or structural measures associated with the No Action Alternative. On Crescent Island, approximately 2.4 acres of potential Caspian tern nesting habitat has been covered with passive nest dissuasion materials consisting of fencerows. Open areas on Crescent Island were planted with willow and other native vegetation prior to the 2016 nesting season.

Water surface elevations under current operations, which influence the distribution and maintenance of wetland habitats, would continue and current trends for habitat quality, quantity, and distribution would not deviate from current conditions. The distribution and acreage of wetland habitat in the upper portion of Region D (The Dalles and John Day study areas) is limited due to the close relationship of highways and railroads to the river's shorelines. Forested and scrub-shrub and emergent herbaceous wetlands occur in embayments formed by the location of highways and railroads adjacent to the river at elevations of 14 to 26 feet, above which habitats transition abruptly to upland land cover types. In the lower portion of Region D (downstream of The Dalles Dam), the distribution and acreage of wetland habitats increases, becoming extensive throughout the lower Columbia River, where emergent herbaceous wetlands occur at elevations of 1 to 10 feet. Wildlife use of habitats would not change in response to operations or structural measures associated with the No Action Alternative.

There is very little erosion or bank sloughing in the upper portions of Region D (The Dalles and John Day study areas) due to shorelines consisting almost entirely of bedrock. Under the No Action Alternative, these patterns would not change and factors influencing shoreline conditions, such as high-flow years or low-flow years, would continue. Under the No Action

Alternative, patterns of accretion and erosion in the lower portions of Region D would not change substantively from current conditions, and factors influencing shoreline conditions and erosional patterns, such as high-flow years or low-flow years, would continue similar to current conditions. As a result, due to increasing erosion in the lower portions of Region D, the spatial extent and acreage of sandy shorelines is expected to decline, reducing habitat available for species using these habitats.

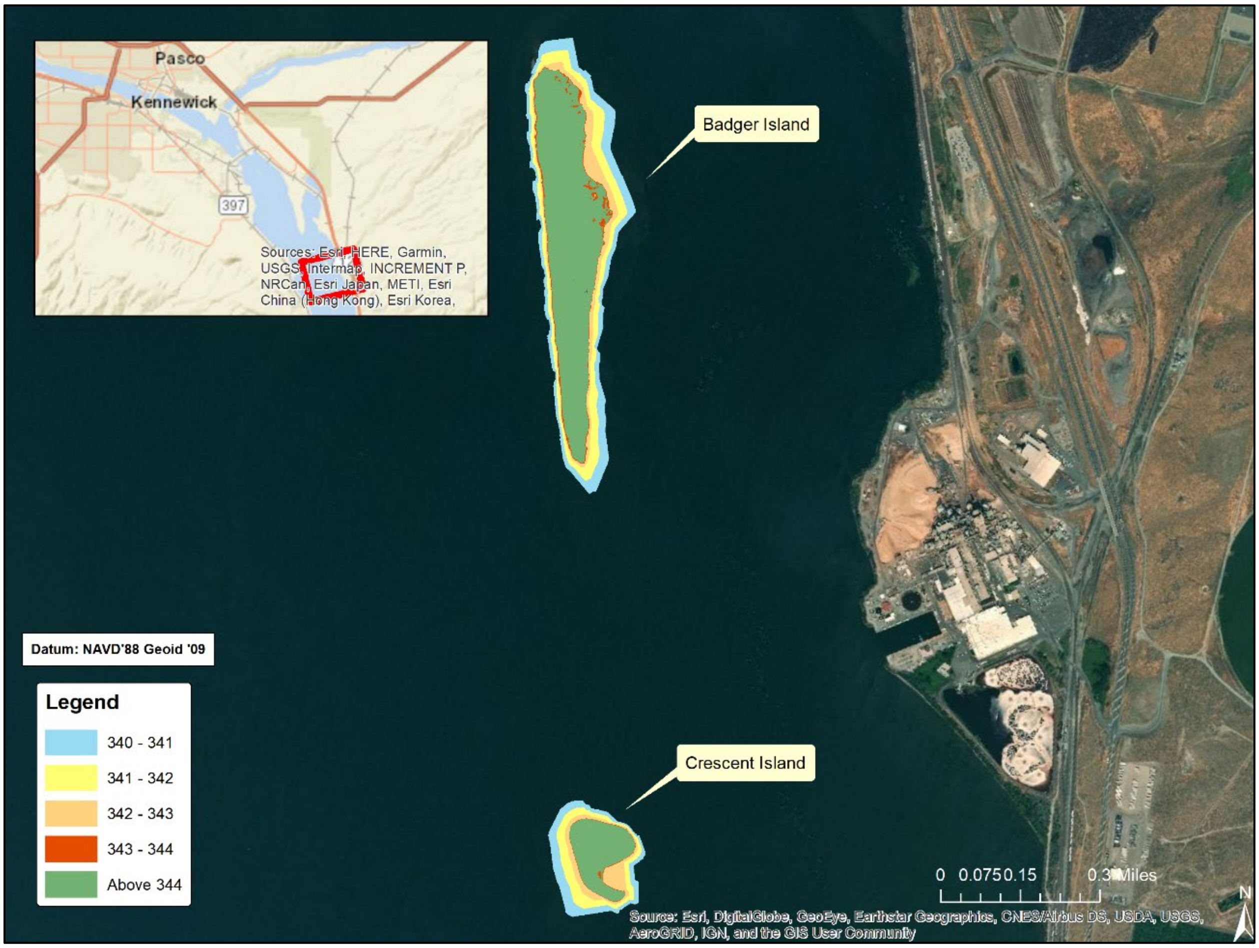



**Figure 3-149. Crescent Island in McNary Reservoir**

Note: Legend units are feet.

Downstream of The Dalles Dam, the ecosystems begin shifting from warmer, drier habitats to cooler, wetter habitats. Upland habitats downriver from Bonneville Dam vary between wet, cool forests west of the Cascade Range to oak savannahs near Vancouver, Washington, and Portland, Oregon, to coastal forests near the ocean. The river banks transition from bedrock shorelines near Bonneville Dam and the Columbia River Gorge to sandy beaches near the coast, with rock- or dirt-fill levees throughout much of the lower river. Habitat conditions associated with the levees would continue under the No Action Alternative. As described above, it is assumed that routine operations and maintenance of levees would continue and in areas that are not regularly maintained, current levels of existing erosion or degradation would continue.

Throughout Region D, USFWS, ODFW, and WDFW manage emergent herbaceous and forested and scrub-shrub wetland habitat to support fish and wildlife habitat. The No Action Alternative assumes USFWS would continue to implement management activities consistent with refuge goals and agency policies for the benefit of fish and wildlife in the lower river. As a result, it is assumed that management activities at McNary, Umatilla, Franz Joseph, Pierce, Steigerwald, Ridgefield, Julia-Butler Hansen, and Lewis and Clark National Wildlife Refuges (NWRs) would maintain habitat conditions similar to current conditions. The Umatilla NWR would continue to support valuable habitat for fish and wildlife under the No Action Alternative, and McCormick Slough on Lake Umatilla would continue to provide valuable habitat for wintering waterfowl in the Umatilla NWR Important Bird Area (IBA) (Figure 3-150). Concentrations of ducks and geese over-wintering in the study area are anticipated to continue in numbers consistent with current trends under the No Action Alternative. The Rock Creek IBA in Washington near The Dalles, Oregon, is anticipated to continue providing valuable shrub-steppe habitat for a multitude of bird species, including ash-throated flycatchers (*Myiarchus cinerascens*) and California scrub jays (*Aphelocoma californica*). Conditions in these habitat areas would remain the same under the No Action Alternative.

Similarly, the Blalock Islands and surrounding low-lying sand and gravel bars, located between RM 272 and 277, are anticipated to continue providing suitable habitat for breeding Caspian terns, gulls, and other waterbirds under the No Action Alternative (Figure 3-151 and Figure 3-152).

Under the No Action Alternative, no management activities would occur to modify or change the suitability of habitats in the Lake Umatilla study area to support or preclude breeding habitat. Currently, John Day Dam is managed to maintain water surface elevations in Lake Umatilla at elevations between 257.0 and 268.0 feet NGVD29 (NAVD88) with normal pool operations changing seasonally. The normal operating range for Lake Umatilla is between 262.5 - 265.0 feet in October, 262.0 - 266.5 feet November through December, 262.0 - 265.0 feet January 1 - March 14, 262.5 – 265.0 feet March 15 – April 9, and between 262.5 and 264.0 feet April 10 – September 30. Slight deviations from these levels could occur occasionally (e.g., to meet navigation requirements, or hydropower needs). John Day Dam operates for flood risk management and Lake Umatilla will draft to as low as 257.0 feet and may fill to a maximum pool of 268.0 feet during flood operations. Under the No Action Alternative operations, approximately 3.6 acres of suitable habitat is available in the Blalock Islands complex during the breeding season for nesting Caspian tern. The total acreage available for nesting terns does not occur as one colony site but is instead fragmented between several low-lying islands with no or very limited vegetation.

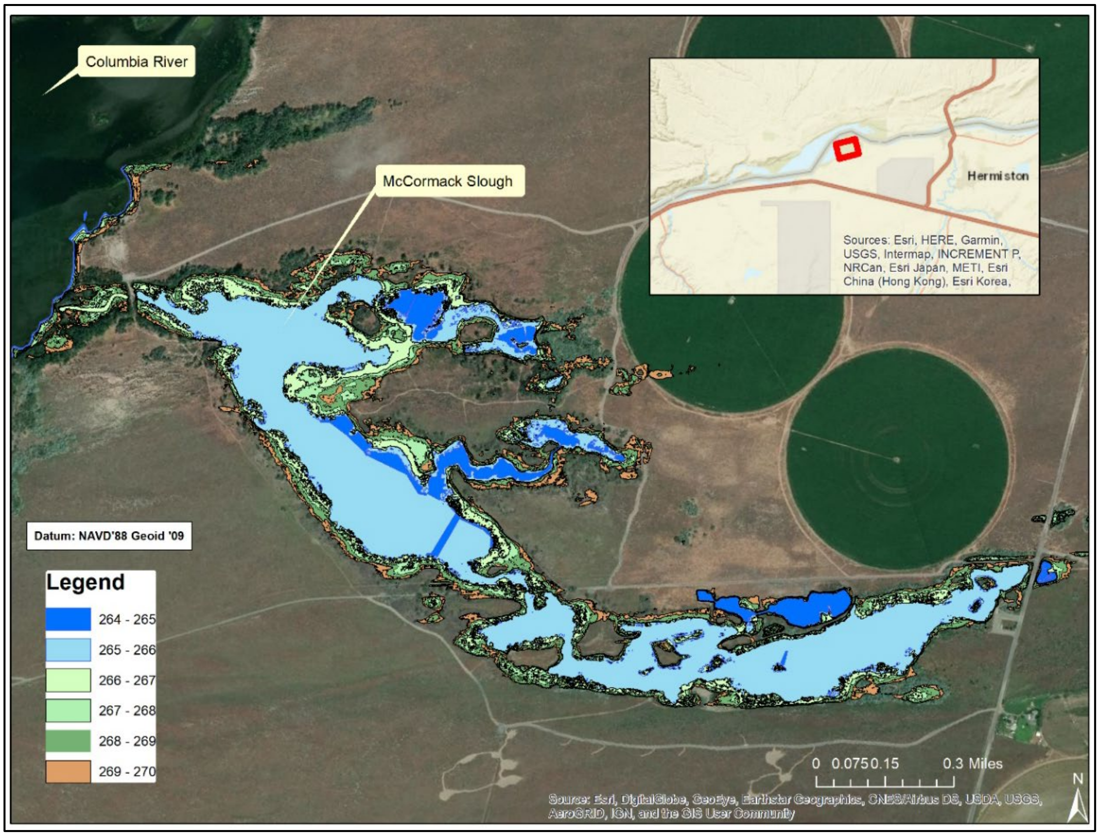



**Figure 3-150. McCormack Slough in the Umatilla National Wildlife Refuge at River Mile 273**

Note: The slough is a shallow water habitat environment that is part of the USFWS-managed Umatilla NWR downstream of McNary Dam. The legend units are feet NAVD88.

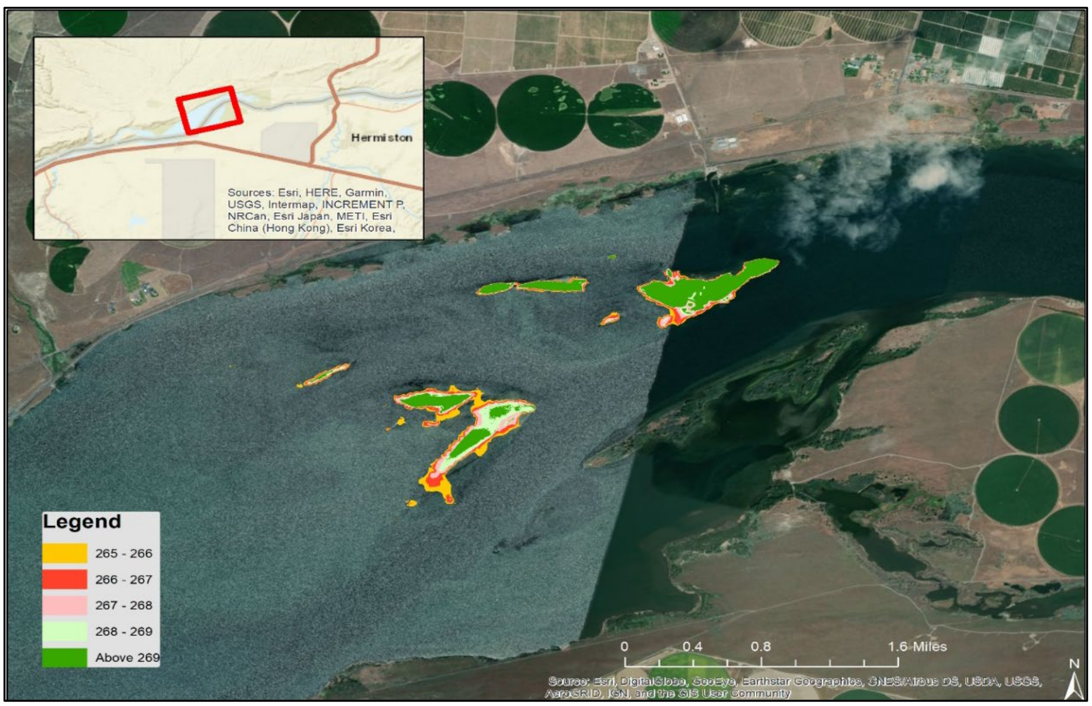



**Figure 3-151. Blalock Islands Complex in the Lake Umatilla at River Mile 273**

Note: The island complex is part of the USFWS-managed Umatilla NWR downstream of McNary Dam.

As mentioned above, operations and maintenance actions at ODFW- or WDFW-managed lands and habitat for the benefit of wildlife are assumed to continue similar to current practices under the No Action Alternative. This includes Klickitat Wildlife Area near RM 180 for western pond turtle (*Actinemys marmorata*) and Sondino Ponds in Washington. As a result of these collective actions, it is assumed that wildlife concentrations and use of habitats in the lower Columbia River would not change from current conditions in response to the No Action Alternative.

The Corps currently implements management activities at and downstream of John Day Dam, The Dalles Dam, and Bonneville Dam to reduce avian predation on juvenile salmonids by gulls and terns. These activities include the maintenance of avian wires spanning the river (effectively bank to bank), in an effort to minimize large concentrations of birds congregating at juvenile bypass outfalls where they can more easily prey upon juveniles exiting the bypass systems. The Corps, with support from USFWS and U.S. Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services, also implement management activities to limit the availability of nesting habitat for Caspian tern and double-crested cormorant (*Phalacrocorax auratus*) at East Sand Island at RM 5.5. These management activities include hazing birds from areas outside of a designated colony area, for example, limiting the availability of habitat for Caspian tern to 1.0 acre through habitat management by removing unwanted vegetation and installing dissuasion materials to delineate a 1.0-acre breeding colony. Under the No Action Alternative, management activities would continue and include coordinating with the USFWS for authorization to haze birds from nesting habitat outside the managed 1 acre, and collect eggs in order to limit nest establishment. These management activities at East Sand Island in the Columbia River estuary, which are outlined in the Caspian Tern Management to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary EIS (Corps 2014) and Double-crested Cormorant Management Plan to Reduce Predation of Juvenile Salmonids in the Columbia River Estuary EIS (Corps 2015), would continue. The effects of these management actions on Caspian terns and Double-crested cormorants are to limit reproductive success, manage population growth, and specific to Terns, relocate some of the nesting population to habitat outside the Columbia River Basin.

In an effort to curb pinniped (seal and sea lion) predation on ESA-listed salmonids, regional fish and wildlife agencies implement management actions to selectively remove (lethally and non-lethally) sea lions observed repeatedly feeding on salmon and steelhead below Bonneville Dam on the Columbia River. Between 2008 and 2016, a total of 144 individual California sea lions were lethally removed (euthanized) from waters below Bonneville Dam, 15 animals were relocated to zoos or aquariums, and 2 died in traps. These actions are expected to continue under the No Action Alternative, with increasing numbers of sea lions lethally removed from the population as capacity in zoos or aquariums declines.

**Figure 3-152. Caspian Tern Nesting Colonies in 2018 at Middle and Long Islands in the Blalock Islands Complex**

Source: Bird Research Northwest (2019)

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.

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

McNary Dam. Further, the 34,000-acre Pine Creek Conservation Area in Wheeler County, Oregon, is owned and managed by the Confederated Tribes of Warm Springs. In total, ongoing Bonneville F&W Program wildlife mitigation projects for Region D dams total over 107,000 acres.

**FLOODPLAINS**

It is assumed here that the current probability of inundation for the existing active floodplains would continue under the No Action Alternative. Therefore, there would be no change in active floodplain benefits under the No Action Alternative.

**SPECIAL STATUS SPECIES**

Table 3-102 provides details about ESA-listed wildlife species that are known or are likely to occur in the study area. Over the 25-year period of analysis, it is assumed that those species federally listed and present in the study area will remain listed and existing regulatory and best management practices would reduce the likelihood that populations would continue declining or go extinct. It is assumed that neither grizzly bear (*Ursus arctos horribilis*) critical habitat nor the whitebark pine (*Pinus albicaulis*) would be listed and their presence and population in or near the study area would remain relatively stable.

**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 | *Ursus arctos horribilis* | ESA status: T<br>CH: proposed | Relatively undisturbed mountainous, closed and open timber, mixed shrubs (alder/huckleberry), meadows, seeps, and riparian zones.<br>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.<br>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.<br>Critical habitat is proposed in Albeni Falls study area near Pend Oreille. | Libby<br>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 | *Odocoileus virginianus leucurus* | ESA status: T<br>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 | *Zalophus californianus* | ESA status: None<br>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 | *Eumetopias jubatus* | ESA status: None<br>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 | *Orcinus orca* | ESA Status: E<br>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 | *Coccyzus americanus* | ESA status: T<br>CH: Proposed | Low elevation, open woodland and deciduous riparian vegetation adjacent to rivers and streams in western United States.<br>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.<br>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.<br>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.<br>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.<br>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 | *Haliaeetus leucocephalus*<br>*Aquila chrysaetos* | ESA Status: none<br>CH: none<br>Bald and Golden Eagle Protection Act | Bald eagle roost and nest in large trees adjacent to the river shoreline.<br>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 | *Eremophila alpestris strigata* | ESA status: T<br>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 | *Spiranthes diluvialis* | ESA status: T<br>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<br>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). |

Note: C = Candidate for listing; CH = Designated Critical Habitat; E = Endangered; PT = Proposed for listing as Threatened; T = Threatened.

**SUMMARY OF EFFECTS**

Under the No Action Alternative, current mitigation measures, such as juvenile fish transport, salmon and steelhead hatchery production, and avian predation control, would continue, affecting prey availability in the lower Columbia River. Water and sediment quality conditions (water temperatures, thermal conditions, nutrients, and pollutants) and their effects on wildlife would continue under the No Action Alternative. Patterns of erosion and subsequent sediment accumulation behind the Federal dams would continue, trapping potential contamination behind the dams, leading to bioaccumulation in benthic and aquatic organisms. Furthermore, trapping sediments behind the dams disrupts natural sediment transport processes, increasingly resulting in downstream reaches becoming starved of sediment. As a consequence of this, accretion processes in the lower river are diminished, leading to loss of wetlands and mudflats. These patterns are expected to continue under the No Action Alternative. Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue, including protection, mitigation, and enhancement of wildlife habitat as discussed in Section 5.2.1.

As dam operations, and the frequency, timing, depth, and duration of flows throughout the Columbia River Basin, would be similar to existing conditions, the driving ecological and anthropogenic processes that currently influence wildlife habitat and populations would remain largely consistent over the 25-year period of analysis. Because the current probability of inundation for the existing active floodplains would continue under the No Action Alternative, there would be no change in floodplain benefits. Riparian vegetation that is dependent on the natural riverine freshet, such as cottonwoods, would continue to decline in some areas where the hydrology of the floodplains has been altered. Unless otherwise described below, the amount and type of vegetation wildlife habitat and wildlife species present under the No Action Alternative would remain consistent with that described in Section 3.6.2 (Affected Environment).

Under the No Action Alternative, wildlife would continue to be influenced by availability of habitat, natural processes including fire and human-wildlife interaction through recreation, including hunting. Where human disturbance increases, wildlife may experience adverse effects and temporarily or permanently relocate to alternative habitat areas with little or no disturbance. Conversely, wildlife would experience beneficial effects from implementation of habitat restoration actions to meet local, state, and regional habitat objectives. The rich diversity and abundance of wildlife throughout the Columbia River Basin would continue in a manner similar to existing conditions described in Section 3.13.1, as would the seasonal fluctuations in wildlife numbers and diversity resulting from the presence of large numbers of migratory wildlife. Mammals, migratory game birds, reptiles and amphibians, and terrestrial and aquatic invertebrates would remain abundant in the study area. Winter conditions that influence predator/prey relationships are not expected to change from current conditions, and existing patterns of predation would continue.

#### *3.6.3.3 Multiple Objective Alternative 1*

Chapter 2, *Alternatives*, contains a description of how the CRS would be operated under MO1. A full description of the alternative can be found in Section 2.4.3.

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

Three operational measures would be implemented at Libby Dam, which differ from current operations as described under the No Action Alternative: the *Modified Draft at Libby*, *December Libby Target Elevation*, and *Sliding Scale at Libby and Hungry Horse* measures. Refer to Chapter 2, *Alternatives*, and Table 2-3 for a description of these measures.

During spring months and the early part of the growing season, water levels under the *Modified Draft at Libby* measure would drop approximately 2.5 feet below average to account for deeper drafts. Changes in a high- or low-water year may have another effect. The increase in annual peak outflow from Libby Dam has a small impact on peak flows downstream in the Kootenai River; however, decreased outflow in May generally translates to a decrease in freshet peaks. Following an increase in water surface elevations in February and March, water surface elevations in the Kootenai River would decrease in April and May by approximately 1 foot in average years from the implementation of the *Modified Draft at Libby* measure under MO1. This change in water surface elevations would potentially alter wetland habitat types throughout the Kootenai River.

By implementing the *December Libby Target Elevation* measure, Libby Dam would be operated to reduce the frequency of overdrafting the reservoir when years are drier than initially forecast by establishing a new end-of-December draft target of 2,420 feet NGVD29 (NAVD88), an increase of 9 feet from the No Action Alternative. This would allow for less variability in pool elevation as opposed to the wider range of December elevations under the No Action Alternative. As a result of this new draft target under the *December Libby Target Elevation* measure, winter water levels in the reservoir would increase, peaking in January when the pool elevation would be 7 feet higher than the No Action Alternative. The primary habitat affected by the new end-of-December water surface elevation would be the barren area, or barren zone.[2] Implementing the *December Libby Target Elevation* measure would reduce the spatial extent of the barren area by approximately 9 (vertical) feet around the reservoir during most years, increasing the wetted area during the winter months. The area of land between 2,411 feet and 2,420 feet would not freeze as in previous years under the No Action Alternative, allowing for potential vegetation establishment in the spring as a result of increased viability of seeds that do not freeze over the winter.

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[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.

The *December Libby Target Elevation* measure would provide additional stability to beaver (*Castor canadensis*) colonies on the lower Kootenai River due to decreased variability in December flows. The beaver is considered an "ecosystem engineer," constructing dams that impound water and increase, diversify, and support wetland vegetation communities (Wright, Jones, and Flecker 2002). The *December Libby Target Elevation* measure would have trickle-down effects immediately benefiting aquatic wildlife and herbivores, such as amphibians and white-tailed deer (not Columbia White-tailed Deer).

Operational changes at Libby Dam under MO1 can be seen throughout the Kootenai River system during most months but are increasingly diluted from tributary inputs downstream of the dam from the Fisher, Yaak, and Moyie Rivers. The largest downstream changes occur in December when outflows decrease by 4 to 5 kcfs, rapidly followed by an increase in outflows in February of up to 3.3 kcfs. Operational changes would cause water levels to fluctuate at the Kootenai Falls Wildlife Management Area (RM 202) from 1.3 feet lower in December (relative to the No Action Alternative) to an increase of 1.2 feet in February and March. Water level fluctuations in March would inundate narrow bands of emergent vegetation along the Kootenai River shoreline adjacent to the wildlife management area at the start of the growing season. However, the wildlife managed at Kootenai Falls Wildlife Refuge are primarily upland species, including mule deer, bighorn sheep, and white-tailed deer (MFWP 2016). Under MO1, changes to wetland vegetation from the proposed operations would not have measurable effects to species in this area.

The *Sliding Scale at Libby and Hungry Horse* measure would increase growth and expand wetlands where they occur at tributary confluences, like the Tobacco River, especially late in the summer months when conditions for wildlife are generally warmer and drier. The biologically rich transition zone between emergent herbaceous, and forested and scrub-shrub wetlands would shift laterally, increasing the overall spatial extent of wetland habitats in the immediate vicinity of Lake Koocanusa relative to the amount of wetland habitats that occur under the No Action Alternative.

Higher water surface elevations within Lake Koocanusa from the *Sliding Scale at Libby and Hungry Horse* measure would also increase the area of open-water habitat and reduce the barren area, and therefore decrease the rates of predation of small wildlife. Higher water levels during summer months (June through September) would increase the inundation levels within adjacent wetlands during the growing season, resulting in a reduction of existing emergent wetland vegetation or a transition in plant communities to species that can tolerate patterns of regular inundation. These changes would impact nesting waterfowl by reducing the amount of woody vegetation along the shoreline available during the breeding season.

With spring and summer, water levels in the Kootenai River are typically several inches lower compared to the No Action Alternative, MO1 operational changes at Libby Dam would likely cause small habitat changes, such as drying of shallow backwater areas. This could affect wildlife such as the western toad by causing immotile amphibian eggs to desiccate.

Aquatic invertebrates, like caddisflies and stoneflies, would experience similar interruptions in life cycle, which could lead to changes in the food web and a corresponding decrease in food availability throughout the area thereby affecting wildlife species that feed on them (See Section 3.5, *Aquatic Habitats, Aquatic Invertebrates, and Fish*).

Under MO1, Hungry Horse reservoir would experience a deeper drawdown during most months that would expose more of the barren area surrounding the reservoir and would create higher predation risk for wildlife. During late fall and winter, the barren area would not be noticeable to wildlife, as the area is typically covered in snow and the reservoir freezes over for many months. During the spring and early fall, when the barren area is exposed and would be larger than that which occurs under the No Action Alternative, wildlife would be at increased risk of predation as they traverse the area to reach the reservoir. This would be a minor effect on wildlife.

The increased barren area would have negligible (if any) impact on birds in the area. The time period when the reservoir would experience the greatest change under MO1 is during the winter months when there is little bird activity at Hungry Horse.

Downstream of Hungry Horse Reservoir, along the South Fork Flathead River, the effects from implementing MO1 would be negligible. The changes in water level are typically less than 0.2 foot (approximately 2.4 inches). This marginal change would not alter floodplain function, wetland habitats, vegetation communities, or wildlife populations in the Hungry Horse study area compared to the No Action Alternative. Current trends associated with plant communities, including willows and cottonwoods, are expected to continue similar to the trends described under the No Action Alternative. While there would be a small increase in water surface elevation in the Flathead River downstream of Hungry Horse Dam in August and September due to increased outflow for water supply through implementation of the *Hungry Horse Additional Water Supply* measure, the effects of this increased water on existing habitats would be negligible In the Flathead River, effects would be even less pronounced and would become increasingly diluted downstream.

Under MO1, no structural changes would be implemented at Albeni Falls Dam or within the Albeni Falls study area. Similarly, no changes would be made to Albeni Falls Dam operations in most water years. Results from H&H modeling and analysis show that higher flow periods in the winter and spring would be slightly lower due to changes at Hungry Horse, resulting in slightly lower water levels compared to the No Action Alternative. The differences in monthly water surface elevations (less than 6 inches) is typically within the expected range of natural variability. Thus, negligible impacts to floodplains are expected from the implementation of this proposed measure. Because the annual average probability of inundation would remain unchanged from current conditions, negligible impacts to floodplains are expected.

In most years, implementation of MO1 would have no effect on vegetation or wildlife in the Albeni Falls study area and conditions would remain unchanged from the No Action Alternative. However, during high-flow conditions, water surface elevations downstream of the dam would decrease by as much as 5 inches in November relative to patterns observed under the No

Action Alternative. Despite lower water surface elevations, implementing the *Hungry Horse Additional Water Supply* measure under MO1 is not expected to alter the type, location, or abundance of vegetation, floodplain function, wildlife habitat, or wildlife populations in the Albeni Falls Dam study area. Because river levels would drop less than 6 inches during high water events outside of the growing season, it is highly unlikely that habitats would functionally change in response to the *Hungry Horse Additional Water Supply* measure. Consequently, no effects to wildlife populations are expected from the implementation of this proposed measure.

The operational changes from implementing MO1 would result in small changes in the Lake Koocanusa study area and would therefore have negligible effects on wildlife populations. Similarly, MO1 is not expected to impact any wildlife populations downstream of Libby, Hungry Horse, or Albeni Falls Dams. Similar to the No Action Alternative, trends of reduced riparian vegetation establishment due to higher winter flows would be expected to continue, as observed in the Flathead River study area. The gradual loss of deciduous woody plant communities and conversion to coniferous uplands and forested and scrub-shrub wetlands would lead to a loss of biodiversity and degraded ecosystem function in the Libby Dam study area (Kootenai Tribe of Idaho [KTOI] 2013). Despite these changes, it is anticipated that habitat conditions in Region A and sections of the Kootenai, Flathead, and Pend Oreille Rivers downstream from dams would stabilize after several years under MO1. Efforts to restore black cottonwood galleries, as described under the No Action Alternative, would continue.

The operational changes at Libby Dam from MO1 would also be evident in downstream reaches of the Columbia River, as discussed in the Regions B and D sections below.

In regard to potential effects in Canada, the effects to vegetation and wildlife resources and their habitats under MO1 are expected to be similar to the effects described for the United States portion of Region A.

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

At Grand Coulee Dam, there are five operational measures under MO1 that have the potential to impact habitats, floodplains, and wildlife populations in the study area: the *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, *Grand Coulee Maintenance Operations*, *Winter System FRM Space*, and *Lake Roosevelt Additional Water Supply* measures. Collectively, these measures influence water surface elevations in Lake Roosevelt and downstream reaches of the Columbia River, as well as the outflow from Grand Coulee Dam, resulting in changes to the quantity, quality, and distribution of habitats in the study area. Changes to wildlife habitats have a corresponding effect on wildlife populations in the study area.

The *Winter System FRM Space* measure would decrease water surface elevations immediately upstream of the dam in Lake Roosevelt by approximately 5 to 6 feet during the winter months (January through March, with less than a foot difference in April) in most years, when compared to the No Action Alternative. The effects of this decrease would be evident throughout the Lake Roosevelt system all the way to U.S.-Canada border, but decrease to a loss of approximately 3 feet in elevation (or depth) farther upstream. Such a large decrease in water surface elevation across the study area would impact wildlife habitat similar to the changes expected at Libby Dam. The frequency and duration of drying conditions would increase for areas with emergent herbaceous and forested and scrub-shrub wetlands, and these habitats would transition into upland habitats, or plant communities in these habitats would transition to predominantly species more tolerant of dry conditions. This would change plant composition and distribution, or reduce the overall quantity of wetland acreage.

The *Lake Roosevelt Additional Water Supply* measure would increase the exposure time of the barren area around the perimeter of Lake Roosevelt in response to decreased water surface elevations in the winter and spring months. Because the growing season (April through October) overlaps with decreased water surface elevations in Lake Roosevelt, changes to growing conditions and plant communities would result from implementation of this measure.

These changes to habitat are expected to reduce overwintering habitats for wintering waterfowl and diving ducks, as well as wildlife populations supported by wetland habitats in the Grand Coulee Dam study area. The gradual loss of deciduous woody plant communities and potential conversion to upland plant communities would lead to a loss of biodiversity and degraded ecosystem function. However, despite these changes it is anticipated that habitat conditions in Region B and sections of the Columbia River downstream from Chief Joseph Dam would stabilize after several years under MO1.

Under the *Planned Draft Rate at Grand Coulee* and *Winter System FRM Space* measures, lower water levels in Lake Roosevelt would persist longer into the spring months compared to the No Action Alternative. As a result, emergent herbaceous and forested and scrub-shrub wetlands would transition to drier habitat types and the composition of plants would shift to primarily species more tolerant of drier conditions, thereby reducing the overall quantity, distribution, or functional quality of wetland habitats in the study area. As a result, these changes would negatively impact the health and development of forested and scrub-shrub wetlands where gallery forests or tree stands, such as stands of black cottonwood (*Populus trichocarpa*), are the predominant tree species supporting bald eagle nests in the study area. Shallow backwater habitat would become intermittently dry as water surface elevations decrease, causing immotile amphibian eggs, like those of the western toad, to desiccate. Because of the lack of vegetation or other habitat cover in the barren zone, small mammals (i.e., mice, voles, and shrews) would experience increased rates of predation, as they would be more susceptible to predators foraging along the reservoir shoreline. Areas that establish as emergent herbaceous wetlands would provide increased protection for some animals, as well as increased overall biodiversity and productivity along the reservoir.

Changes to water levels or fluctuating water conditions in Lake Roosevelt in response to the *Winter System FRM Space* measure would impact foraging behaviors of diving ducks and other waterfowl by changing the quality and quantity of open-water habitat and shallow-water areas for foraging. The common loon (*Gavia immer*) overwinters in Lake Roosevelt, foraging in open-water habitats and shallow-water areas with emergent or submerged vegetation from October through March. When water surface elevations are lower, the availability of open-water habitat with suitable foraging material would be reduced. When shallow-water areas become exposed, emergent vegetation would no longer be available as forage, decreasing overwintering habitat conditions for wintering waterfowl.

Decreased water surface elevations in Lake Roosevelt associated with MO1 would influence predator populations, as well as ungulate populations in the Grand Coulee Dam study area. Increasing the barren area during winter under lower water surface elevations would impact ungulate populations, such as bighorn sheep. More barren area habitat would provide increased area for mountains lion to hunt and kill prey animals, which could result in higher predation rates on the local ungulate (i.e., elk, deer, and bighorn sheep) population.

Upstream of Grand Coulee Dam, the decreased water surface elevations during the winter and early growing seasons would impact plant communities and wetland habitats adjacent to the shoreline, any changes in those habitats (e.g., changed plant composition or distribution, or reduction in overall quantity of wetlands) would impact foraging and sheltering habitats, resulting in effects to migratory wildlife, such as birds or large mammals, utilizing these areas.

The operational changes at Grand Coulee Dam under MO1 are also evident throughout the Columbia River System, as discussed below in Region D. In regard to potential effects in Canada, the effects to vegetation and wildlife resources and their habitats under MO1 are expected to be similar to the effects described for the United States portion of Region B.

At Chief Joseph Dam, MO1 includes the *Chief Joseph Dam Project Additional Water Supply* measure, which diverts up to 9,600 acre-feet of water from the Columbia River during the irrigation season (April through October) to support irrigation on authorized lands downstream from the dam. The growing season in the Chief Joseph study area is from April to November; the diversion directly overlaps this time period. The measure contributes to decrease in river flow river flow below Chief Joseph Dam. The loss of this water from the river system is relatively small compared to the much larger changes in flow resulting from the *Lake Roosevelt Additional Water Supply* measure at Grand Coulee. As a result, there are no noticeable effects on water surface elevations immediately downstream from Chief Joseph Dam, related to the *Chief Joseph Dam Project Additional Water Supply* measure, and the measure is not expected to result in a measurable impact to habitats or wildlife populations upstream or downstream of Chief Joseph Dam. Wildlife mitigation actions would continue to be consistent with actions described under the No Action Alternative.

Changes in water levels at the upstream ends of Chief Joseph Reservoir and the other projects through the middle Columbia River reach (Wells Dam, Priest Rapids Dam, etc.) would occur as a result of the changes in outflow from Grand Coulee Dam. The same is true for the Hanford Reach below Priest Rapids Dam. Flow and water levels are generally increased in December as a result of the *Winter System FRM Space* measure, and decreased from February through September, mostly from the *Lake Roosevelt Additional Water Supply* measure. Both the increase in December water levels and the decrease later in the spring through the summer are typically 0.5 foot or less. These changes would be evident in most of the free-flowing Hanford

Reach downstream of Priest Rapids Dam, but are negligible within most of the reservoirs between Grand Coulee and Priest Rapids. These changes are expected to have a negligible effect on wildlife. Reaches of the Columbia River upriver from McNary Dam (i.e., the Hanford Reach) are affected by the *Planned Draft Rate at Grand Coulee* and *Winter System FRM Space* measures at Grand Coulee Dam resulting in changes to the quantity, quality, and distribution of habitats in the study area.

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

Under MO1, the *Dworshak Temperature Control* measure would result in changes to Dworkshak Reservoir elevation from June through September. Water levels are consistently lower June 20 through August 1, typically between 3 and 8 feet. From August 1 to August 31, draft slows dramatically and the deeper reservoir transitions to being about 10 feet higher by August 31 in most years compared to the No Action Alternative. For the first half of September the water levels are about 10 feet higher compared to the No Action Alternative, but then match the No Action Alternative by September 30 at 1,520 feet NGVD29 (NAVD88).

This measure would result in changes to the quantity, quality, and distribution of habitats in the study area. Changes to wildlife habitats have a corresponding effect on wildlife populations in the study area. Lower water levels in June, July, and August would cause amphibian eggs along the shoreline to dry out and would create a larger barren area for small mammals to cross.

Emergent vegetation would establish itself in some portions of the barren area during the early part of the growing season (April through June), transitioning these areas into emergent herbaceous wetland habitats.

Water levels on the Clearwater River downstream from Dworshak Dam would be more than 1 foot higher in most years in late June and mid-September, about 0.5 foot higher in July, and as much as 2 feet lower in August, associated with the changes in water surface elevations following increased outflow from the *Modified Dworshak Summer Draft* measure. This change would diminish to zero at the downstream end of the reach, within the influence of the Lower Granite Reservoir. However, this change would be similar to the natural variability of flows observed under the No Action Alternative. Forested and scrub-shrub wetlands in low-lying areas along the Clearwater River would experience slightly prolonged inundation into the early summer months (June and July) following implementation of the *Modified Dworshak Summer Draft* measure. While the increase in water surface elevation is marginal, it would be sufficient to inundate shallow off-channel habitat or forested and scrub-shrub wetlands.

Because of the lack of vegetation or other habitat cover in the barren zone, small mammals (i.e., mice, voles, and shrews) would experience increased rates of predation, as they would be more susceptible to predators foraging along the reservoir shoreline. Areas that establish as emergent herbaceous wetlands would provide increased protection for some animals, as well as increasing overall biodiversity and productivity along the reservoir. Ground-nesting birds would not be affected by operational changes at Dworshak Dam that influence pool elevations because the shorelines around the reservoir are steeply sloped and preclude suitable nesting habitat for birds. Similarly, there are no islands in the reservoir that support breeding or nesting habitat under the No Action Alternative and no new or additional island habitat would be exposed under MO1. As a result, MO1 is not expected to result in changes to accessibility to prey resources or foraging habitat for fish-eating birds, bald eagles, diving ducks, or other waterbirds. Changes in water surface elevations and outflow from Dworshak Dam are successively diluted in the Clearwater River downstream from its confluence with the lower Snake River. Any changes in operations at Dworshak Dam are not measurable in lower Snake River. Consequently, there would be no anticipated changes to shoreline habitats for ground-nesting birds or increased inundation of wetland habitats to support amphibians under MO1 as compared to the No Action Alternative.

Under MO1, the reservoir elevations at the four lower Snake River dams would differ from those of the No Action Alternative during the MOP season from April 3 through August 31 due to the *Increased Forebay Range Flexibility* measure. At each project, the measure would increase the MOP range from 1.0 feet under the No Action Alternative to 1.5 feet under MO1. There would be no changes beyond the No Action Alternative for the rest of the year. Therefore, the effects to floodplains, wildlife, and vegetation along the lower Snake River would be similar to the No Action Alternative.

This measure would therefore increase the quantity, quality, and distribution of wetland habitats in the Lower Snake River. Emergent herbaceous wetland may become established in new areas where water depth and inundation patterns support the establishment of wetland vegetation and soil conditions. This effect would be negligible. There would be no loss or reduction in the quality and distribution of existing emergent herbaceous and forested scrub-shrub wetlands under MO1 when compared to the No Action Alternative. Existing wetlands would continue to be productive habitats supporting breeding amphibians, reptiles, mammals, and birds during the spring and summer breeding season.

The overall distribution in quantity of invasive species in Region C would remain similar to the No Action Alternative. Where no management efforts are implemented, invasive species are expected to persist under the MO1 similar to the No Action Alternative.

Inundation would support critical temperature and moisture thresholds for breeding amphibians when tadpoles are emerging from eggs. For example, the western toad (*Anaxyrus boreas*) breeds in pools or slow-moving rivers in Montana and Idaho from early May to late June, tadpoles are generally present from late May to early September. The northern leopard frog (*Lithobates pipiens*) breeds slightly later in forested and scrub-shrub wetlands and riparian areas starting in June and ending in September (WDFW 2015). Increasing the quantity and quality of wetted areas during the breeding season would support increased reproductive success and overall fecundity for species susceptible to minor changes in water availability when compared to the No Action Alternative.

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

Under MO1, there would be no changes to the reservoir elevations at McNary Dam, The Dalles Dam, or Bonneville Dam. At John Day Dam, the *Predator Disruption Operati*ons and *Increase Forebay Range Flexibility* measures relate to reservoir operating range. The range in April and May is due to the *Predator Disruption Operations* measure; the range in June through September is due to the *Increased Forebay Range Flexibility* measure. The April - May pool elevations would be approximately 1.0 to 1.5 feet higher than the No Action Alternative.

There are no operational changes at McNary Dam that would influence habitat conditions. While water levels in the Yakima River delta would decrease by approximately 1.5 inches in spring and summer, these changes would also be within the range of natural variability, and daily fluctuations would be similar to the No Action Alternative. Therefore, minor changes to spring and summer water levels would have no effect on vegetation establishment or mudflat exposure. Furthermore, because habitat conditions are not expected to change, there would be no measurable effects on wildlife populations using these habitats. As a result, the changes observed in the H&H model in December for MO1 would have no effect on wildlife populations or their habitats. Flowering rush would continue to establish in exposed mudflats and shallow-water areas similar to the No Action Alternative.

Within the mainstem of the Columbia River, water surface elevations in the river are expected to change by approximately 1 foot above the confluence of the Snake and Columbia Rivers. These changes would result in negligibly wetter conditions than the No Action Alternative.

As described in Section 3.6.2, Affected Environment, and the No Action Alternative, there are forested and scrub-shrub and emergent herbaceous wetlands in the John Day Dam study area in Patterson Slough and McCormack Slough. Increased water surface elevations in April and May would inundate wetland habitats approximately 1.5 feet vertically, including the extensive wetland complex at the Umatilla NWR, thereby temporarily decreasing the amount of vegetated wetlands available to wildlife by approximately 40 percent in the spring and early summer. Despite this prolonged inundation, the temporary nature of inundation is not expected to result in perceptible changes to wetland habitats. Rather, the composition of plants in existing wetland habitats would likely shift to species more tolerant of prolonged inundation. In addition, emergent herbaceous wetlands may become established in new areas where water depth and inundation patterns support establishment of wetland vegetation. As a result, the quantity, quality, and distribution of emergent herbaceous and forested and scrub-shrub wetlands would not change under MO1 compared to the No Action Alternative.

Existing wetlands would continue to be productive habitats, supporting breeding amphibians, reptiles, mammals, and birds during the spring and summer breeding season. These wetland habitats would continue to support regionally important migratory waterfowl overwintering in the Umatilla NWR IBA by providing forage opportunities and prey resources.

Under MO1, the Franz Joseph, Pierce, Steigerwald, Ridgefield, Julia-Butler Hansen, McNary, and Lewis and Clark NWRs along the Columbia River shoreline are expected to maintain habitat conditions similar to existing conditions despite minor changes (less than 3 inches) in water surface elevations in Lake Wallula, Lake Celilo, Lake Bonneville, and downstream of Bonneville Dam. The implementation of the *Increased Forebay Range Flexibility* and *Predator Disruption Operations* measures would not change the quantity, quality, and distribution of wetland habitats and barren areas in Lake Umatilla.

Actions currently implemented under the No Action Alternative that are expected to continue under MO1 include efforts to reduce the spread and establishment of invasive species throughout Region D. A shift in wetland plant composition in Lake Umatilla in response to implementing the *Predation Disruption Operations* measure could effectively increase the distribution of invasive species as they spread into areas where they do not occur under the No Action Alternative. As a result, the overall distribution and quantity of invasive species in Region D could increase under MO1 and reduce habitat quality for some wildlife species. Where no management efforts are implemented, invasive species are expected to persist under MO1, similar to the No Action Alternative.

Between John Day and The Dalles Dams, shorelines are dominated by bedrock, sand, gravel, and sandy deposits, and upland habitats are predominantly shrub-steppe, mixed grasslands, and agricultural areas. Changes in water surface elevations under MO1 would be minor (1 to 3 inches) in all water years (i.e., high-water or low-water years) and would be consistent with the natural range of variability and fluctuations from daily operations. Consequently, the quantity, quality, and distribution of these upland habitat types in Lake Celilo are not expected to deviate measurably from the No Action Alternative. For example, the Rock Creek IBA in The Dalles Dam study area would not be affected from operational measures implemented under MO1, and as a result, habitat in this area would continue supporting wildlife dependent on upland shrub-steppe habitat consistent with the No Action Alternative. For these reasons, implementation of MO1 would not result in a conversion of habitats in The Dalles Dam study area and would therefore result in no measurable effects to wildlife populations.

Downstream of The Dalles Dam, shorelines transition to increased vegetation and wetland complexes, with sandy beaches near the coast. Upland habitats shift from dry shrub-steppe habitat and agricultural areas to oak savannahs and mixed conifer forests. Changes in water surface elevations in the lower Columbia River under MO1 are not expected to alter the quantity, quality, and distribution of these upland habitat types in Region D. On average, the H&H model results show minor changes to water surface elevations (1 to 3 inches) in Lake Bonneville in most water years, and these changes are assumed to be within the natural range of variability given daily fluctuations in operations. As a result, there would be negligible effects to floodplains, habitat, and wildlife in the Bonneville Dam study year across all water years.

As described for the No Action Alternative, several islands in Lake Umatilla are currently available as nesting habitat to fish-eating waterbirds, such as Caspian tern, including the Blalock Islands complex in the Umatilla NWR at RM 273. The *Predator Disruption Operations* measure would inundate nesting habitat on Blalock Islands during the time of year when birds typically initiate nesting activities. The relative proportion of habitat available to nesting Caspian terns under MO1 would be reduced by approximately 72 percent and limited to 0.5 to 1.0 acre compared to the amount available under the No Action Alternative (approximately 3.6 acres). Because the *Predator Disruption Operations* measure would reduce the overall quantity of habitat in Lake Umatilla in April and May, nesting waterbirds throughout the lake would delay nest initiation until water levels dropped and nesting habitat was available in June and July or not nest. Depending on the availability of forage fish and other prey resources in June and July, consistent or long-term delays in nest initiation would decrease overall reproductive success for the colony, reducing the overall fecundity and potentially leading to a long-term reduction in the regional population. Terns that are displaced by these efforts would relocate to other islands. Some terns would relocate to islands within the Columbia River Basin and some would relocate to sites outside the Columbia River Basin. Recent studies show that regional efforts to dissuade Caspian tern nesting have led to a 44 percent decline in the number of Caspian terns nesting in the Columbia Plateau region (Collis et al. 2019). Some of this reduction is due to terns relocating to nesting sites outside the basin.

Decreasing the number of juveniles in the river would decrease overall prey resources supporting a variety of wildlife populations at higher trophic levels (e.g., Caspian tern, gulls, double-crested cormorant, American white pelican, and other waterfowl) or these predators would shift their diet due to change in availability (Meyer et al. 2016). In response, it is expected that wildlife populations dependent on juvenile salmonids as a prey source would transition to other resources, or populations would relocate to other areas where prey resources are more widely available.

Avian nesting habitat on Badger Island, Foundation Island, and Crescent Island would be similar to the No Action Alternative based on similar water surface elevations. Island habitats at Crescent Island and Badger Islands in the McNary Reservoir would be similar to conditions under the No Action Alternative.

The distribution and acreage of wetland habitat in The Dalles Dam and John Day Dam study areas is limited under MO1, similar to the No Action Alternative, due to the proximity of highways and railroads to the shoreline.

Management activities implemented at and immediately downstream of John Day Dam, The Dalles Dam, and Bonneville Dam to reduce avian predation on juvenile salmonids by gulls and terns are expected to continue under MO1. These activities include the maintenance of avian wires spanning the river and active hazing of avian predators around the dams

The H&H model results indicate water surface elevations in Lake Bonneville would remain consistent with the No Action Alternative and would not result in substantive or widespread changes to wildlife populations or their habitats. In locations where ODFW or WDFW manage wetland habitats for wildlife, operations and maintenance actions under MO1 are assumed to continue similar to current practices under the No Action Alternative, including actions at Klickitat Wildlife Area and Sondino Ponds in Washington for western pond turtle. It is assumed that wildlife concentrations and use of habitats in the lower Columbia River estuary would not change under MO1 from current conditions as described in the No Action Alternative.

**FLOODPLAINS**

Under MO1, changes in flood elevations would typically be negligible (absolute value less than 0.3 foot) across the Columbia River Basin for all flood frequencies, from regularly occurring floods (AEP of 50 percent) to the base flood (AEP of 1 percent). Minor reductions in flood elevations (absolute value less than 1 foot) are predicted in Region D for the Columbia River below Bonneville Dam for floods with moderate to low frequencies (AEP values from 15 to 2 percent). Based on these results, the annual average probability of inundation would remain unchanged from current conditions in most of the basin, with minor reductions in inundation frequency below Bonneville Dam. These changes could have minor effects on the floodplain in this reach.

**SPECIAL STATUS SPECIES**

Table 3-103 provides details about ESA-listed wildlife species that are known or likely to occur in the study area and potential effects to these species or their critical habitats in response to implementation of MO1. Similar to the No Action Alternative, it is assumed that federally listed species present in the study area would remain listed and existing regulatory and best management practices would reduce the likelihood that populations would continue declining or go extinct.

None of the special status species, except Ute ladies'-tresses suitable habitat, would be impacted by MO1 beyond No Action Alternative conditions. At Grand Coulee, the variable hydrology would have an effect on Ute ladies'-tresses if a population is found in the study area. Therefore, there may be a negligible effect on Ute ladies'-tresses populations within or downstream of Grand Coulee.

As described in Section 3.5, the fish models predict a small increase in smolt-to-adult returns, and overall abundances of adult salmon and steelhead would lead to a small increase in prey base available to marine mammals foraging in the Columbia River, such as seal or sea lion, or offshore from the mouth of the Columbia River, such as killer whale. In addition, increased spill in MO1 relative to the No Action Alternative is predicted to decrease the number of spring migrating juvenile salmon and steelhead transported to below Bonneville Dam, thereby increasing the number of juvenile fish available as prey in the between McNary Dam and Bonneville dam during the spring. This could increase the prey base available to colonial nesting waterbirds and other fish eating predators in this river reach (Table 3-106).

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**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 | *Ursus arctos horribilis* | ESA status: T<br>CH: Proposed | Libby<br>Hungry Horse | **Construction of structures on the dam:** No effect. No structures are proposed under MO1. Bear are spatially removed from the dam projects.<br>**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.<br>**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 | *Odocoileus virginianus leucurus* | ESA status: T<br>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.<br>**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.<br>**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 | *Zalophus californianus* | ESA status: None<br>CH: None<br>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.<br>**Hydrology**: Negligible effect. Water surface elevation changes minimal (<1 foot) and within range of natural variation.<br>**Prey availability**: Negligible effect. Slight increase in prey availability.<br>**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 | *Eumetopias jubatus* | ESA status: None<br>CH: None<br>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.<br>**Hydrology:** Negligible effect. Water surface elevation changes minimal (<1 foot) and within range of natural variation.<br>**Prey availability:** Negligible effect. Slight increase in prey availability.<br>**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 | *Orcinus orca* | ESA Status: E<br>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.<br>**Hydrology**: Negligible effect. Water surface elevation changes minimal (<1 foot) and within range of natural variation.<br>**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.<br><br>**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 | *Coccyzus americanus* | ESA status: T<br>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.<br>**Hydrology:** Minor effect. Water fluctuations at Libby would result in high winter flows that prevent establishment of cottonwoods galleries.<br>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.<br>**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 | *Haliaeetus leucocephalus*<br>*Aquila chrysaetos* | ESA Status: none<br>CH: none<br>Bald and Golden Eagle Protection Act | Throughout the study area. | **Construction of structures on the dam:** Negligible effect.<br>**Hydrology:** Negligible effect. The bald eagle nests in mature cottonwood trees. Cottonwood trees would continue to decline under MO1.<br>**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 | *Eremophila alpestris strigata* | ESA status: T<br>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.<br>**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.<br>**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 | *Spiranthes diluvialis* | ESA status: T<br>CH: None | Grand Coulee<br>Chief Joseph | **Construction of structures on the dams:** No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected.<br>**Hydrology:** Minor effect. Grand Coulee: Changes in water surface elevations would alter regions along the water margins where the plant could occur.<br>**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. |

Note: C = Candidate for listing; CH = Designated Critical Habitat; E = Endangered; T = Threatened.

**SUMMARY OF EFFECTS**

Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue, including protection, mitigation, and enhancement of wildlife habitat as discussed in Section 5.3.1.3. The effect of MO1 could be summarized by region as discussed in the following sections.

In Region A, under MO1, changes to available wildlife habitat, wetlands, and vegetation would primarily occur in Lake Koocanusa and the Kootenai River. The average annual drop in surface water elevations between April and May in the Kootenai River would dry wetland types along the riverbanks and riparian areas, allowing for colonization of vegetation along the exposed shoreline. Later in the growing season, wetlands would flood. The effect would be a minor effect on wildlife usage. MO1 would provide additional stability to beaver colonies on the lower Kootenai River due to decreased variability in December flows. Ecosystem effects would trickle down, benefiting other wildlife. In Lake Koocanusa, the quantity of barren area around the lake would decrease under MO1, allowing for more potential vegetation establishment around the margins of the lake which would have a minor beneficial effect on wildlife that access the lake.

Also in Region A, the marginal changes in water flows and elevations downstream of Hungry Horse Reservoir, along the South Fork Flathead River, and in the Albeni Falls area from implementing MO1 would not alter wetland habitats, vegetation communities, or wildlife populations compared to the No Action Alternative. Overall, for Region A, there would be a minor effect to wildlife, vegetation, and wetland resources associated with operation of Libby Dam under MO1 and a negligible effect for the other areas in Region A. The annual average probability of inundation would remain unchanged from current conditions, with negligible effects on floodplain benefits in Region A.

In Region B, the largest effect under MO1 to vegetation, wildlife, and habitat would be associated with a large decrease in water surface elevation at Lake Roosevelt. The frequency and duration of drying conditions would increase for areas with emergent herbaceous and forested and scrub-shrub wetlands, and these habitats would transition into upland habitats, or plant communities in these habitats would transition to predominantly species more tolerant of dry conditions. This would change plant composition and distribution, or reduce the overall quantity of wetland acreage. These vegetation and habitat changes are expected to reduce overwintering habitats for wintering waterfowl and diving ducks, as well as wildlife populations supported by wetland habitats in the Grand Coulee Dam area. The size of the barren area during winter under lower water surface elevations would also increase under MO1 and would have an impact on wildlife species and revegetation in these margin areas. Overall, for Lake Roosevelt, there would minor effect on habitat, vegetation, and the corresponding wildlife under MO1. For the other areas in Region B, there would be a negligible effect to habitat, vegetation, and the corresponding wildlife. The annual average probability of inundation would remain unchanged from current conditions in Region B, with negligible effects on floodplain benefits.

In Region C, the summer draft at Dworshak Reservoir would cause a drawdown that would cause a larger barren area and increased drying out of amphibian eggs. While the barren area around the reservoir would be larger, emergent vegetation would be established in some portions of the barren area to form seasonal herbaceous wetlands. Portions of the Clearwater River and island habitats downstream from Dworshak Dam would experience a marginal increase in inundation (1.5 inches) in June and July, associated with changes in water surface elevations following increased outflow from the *Modified Dworshak Summer Draft* measure. While this would be a minor change in inundation, it would represent a minor improvement in habitat for amphibians and birds. Because the lower Snake River Projects are run of the river, there would be a minor change to inundation and inflows. Overall, MO1 would have a minor (Dworshak) and minor (lower Snake River) change to vegetation, habitat, and wildlife in Region C. The annual average probability of inundation would remain unchanged from current conditions in Region C, with negligible effects on floodplain benefits.

In Region D, water surface elevations are expected to largely decrease up to 6 inches during the spring and summer (February through September) within the mainstem of the Columbia River. These changes would be within the range of natural variability and daily fluctuations would be similar to the No Action Alternative. However, water levels in Lake Umatilla would increase by as much as 1.5 feet during the Caspian tern breeding season as a result of the *Predator Disruption Operation* measure. This action would inundate low-lying island habitats upstream of John Day Dam that provide habitat to colonial nesting waterbirds under the No Action Alternative. As a result, there would be less habitat available throughout Region D for colonial nesting waterbirds, such as Caspian terns and gull species. All other changes in river flow and water levels in Region D are expected to stay within the range of normal fluctuations and anticipated to remain the same as under the No Action Alternative. Overall, MO1 would have a negligible effect on vegetation, wetlands, habitat, and wildlife. Minor reductions in the annual average probability of inundation would occur below Bonneville Dam, with minor effects on floodplain benefits in this region.

For special status species in all regions, none of the special status species, except Ute ladies'-tresses suitable habitat, would be impacted by MO1 beyond No Action Alternative conditions. At Grand Coulee in Region B, the variable hydrology could have an effect on Ute ladies'-tresses if the plant were located within the area of effect. Therefore, there may be an effect on Ute ladies'-tresses populations within or downstream of Grand Coulee from MO1. Overall, there would be a negligible to low impact on special status species.

#### *3.6.3.4 Multiple Objective Alternative 2*

Chapter 2, Alternatives, contains a description of how the CRS would be operated under MO2. A full description of the alternative can be found in Section 2.4.4.

MO2 includes the *Ramping Rates for Safety* measure at all storage projects, the results of which would change the rate and magnitude of ramping operations to increase hydropower generation. It would also increase the operational range of the reservoirs to allow for increased flexibility to shape power production to meet demand. Implementing this measure would alter within-day timing, speed, frequency, duration, and magnitude of ramping and result in changes to water surface elevations in reservoirs and along downstream of all projects. Habitats affected by these changes would include shoreline and wetlands, the barren zone, and potentially near-shore aquatic habitats. The nature and magnitude of the effects would depend upon the parameters of specific operations for hydropower generation. Faster ramping rates of longer duration would generally be expected to produce more adverse effects than slower ramping rates or shorter duration. However, because the Ramping Rates for Safety measure would require that ramping rates do not compromise safety or soil stability in the reservoir or downstream of the projects, this measure would not increase erosion or bank sloughing in the study area compared to No Action Alternative conditions.

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

No structural measures would be implemented in Region A as part of MO2. Six operational measures would be implemented in Region A that differ from current operations as described under the No Action Alternative: the *Ramping Rates for Safety*, *Slightly Deeper Draft for Hydropower*, *Sliding Scale at Libby and Hungry Horse*, *Modified Draft at Libby*, *December Libby Target Elevation*, and *Winter System FRM Space* measures. Collectively, these measures alter draft and refill procedures to increase hydropower generation while balancing FRM, adjusting winter pool elevation targets, initiating a sliding scale to draft the pool at Libby and Hungry Horse, and lifting flow and reservoir elevation restrictions.

Under MO2, water surface elevations in Lake Koocanusa would be lower for the majority of the year, specifically in the winter and early summer months, compared to the No Action Alternative. The *December Libby Target Elevation* measure would result in an end-of-November draft target that is 8 feet lower than the No Action Alternative. The MO2 target pool is 7 to 11 feet lower than the No Action Alternative resulting in a deeper draft that continues until the end of February; many of the drier years do not recover the additional space drafted in December. Years with forecasts less than 6.9 Maf have deeper drafts due to the *Modified Draft at Libby* measure. Both the *Modified Draft at Libby* and the *December Libby Target Elevation* measures result in lower water surface elevations in Lake Koocanusa until June. August and September pool elevations would be approximately 0.5 foot higher than the No Action Alternative due to *the Sliding Scale at Libby and Hungry Horse* measures. The primary habitat type affected by these changes would be the barren zone, and emergent herbaceous and forested and scrub-shrub wetland habitats adjacent to the reservoir. In most years, deeper drafts would result in a wider barren zone. As a result, the reservoir pool elevation would be approximately 5 feet lower compared to the No Action Alternative, thereby increasing the area of exposed ground that could be colonized by non-native invasive plants.

The primary habitat type affected by implementing the *December Libby Target Elevation* measure is the barren zone, which would increase by 11.5 feet and 10.3 feet of vertical elevation around the reservoir in December and January, respectively. The *Modified Draft at Libby* measure drafts the reservoir deeper, resulting in a wider barren zone compared to No Action Alternative conditions. A wider barren zone would provide an increased area of exposed ground where small mammals are more vulnerable to predation. Because flowering rush (*Butomus umbellatus*) is present in Flathead Lake in Montana and downstream in the Kootenai River in Idaho, newly exposed mudflats in Lake Koocanusa would provide suitable habitat for establishment of this species, which disperses quickly and degrades overall habitat quality. The relaxed ramping rates and reduced pool elevation restrictions from the *Ramping Rates for Safety* and *Slightly Deeper Draft for Hydropower* measures would cause increased fluctuations in pool elevations and outflow to maximize load shaping for hydropower generation. The effects of changing ramping rates would inundate or desiccate shoreline habitats. Fluctuating water levels also promote flowering rush establishment and population expansion (Hroudová et al. 1996).

Lower water levels in Lake Koocanusa in December through May would reduce hydrologic connectivity of adjacent wetlands, which in turn would lead to decreased productivity in wetlands located at the mouths of tributaries, like the Tobacco River. Because water levels in Lake Koocanusa would drop upwards for 11.5 feet, wetland habitats would convert to upland habitats over time as habitat conditions shift from wetlands supporting willows and cottonwoods to drier conditions supporting more drought-tolerant plant species. As habitats shift, existing vegetation would decrease and cause a temporary increase in the rates of decay and lower dissolved oxygen (DO) levels. Changes in DO affect benthic invertebrates and residual effects to these communities impact the overall food web. Changes less than 0.5 foot would be difficult to measure and are assumed consistent with natural variation and fluctuations in water levels resulting from daily operations. Abrupt changes in pool elevations in Lake Koocanusa during the growing season could inundate and reduce available waterfowl habitat. Water levels in the reservoir would be 3.8 feet and 2.0 feet lower than the No Action Alternative in May and June, respectively, and trend towards a 0.7-foot rise from the No Action Alternative in September. Active nests attached to aquatic vegetation or connected to the shoreline, like those of western grebe (*Aechmophorus occidentalis*), American coot (*Fulica americana*), and cinnamon teal (*Spatula cyanoptera*), may become submerged or disconnected, resulting in decreased productivity or increased rates of predation.

There are few islands in Lake Koocanusa under the No Action Alternative for nesting waterbirds; however, MO2 operations would support exposure of island habitats and development of nesting habitat in the spring and summer. Islands currently inundated under the No Action Alternative, like Cedar, Murray, Kins, and Whites Islands, would be exposed under MO2. Over time, these islands could become established with vegetation and develop into nesting habitat for waterbirds, including Clark's grebe (*Aechmophorus clarkii*); great blue heron (*Ardea herodias*) and black-crowned night heron (*Nycticorax nycticorax*); white-faced ibis (*Plegadis chihi*); Franklin's gull (*Leucophaeus pipixcan*); Caspian tern (*Hydroprogne caspia*), Forster's tern (*Sterna forsteri*), common tern (*S. hirundo*), and black tern (*Chlidonias niger*), all of which are considered species of concern in Montana (Wightman, Tilly, and Cilimburg 2011). Birds that nest early in the nesting season would be able to establish nests and rear young during this timeframe. However, as pool elevations increased in the late summer (July through September), any nests that were still active with eggs or juveniles and within 0.5 foot (vertical distance) of the pool elevation could become inundated, which could lead to nest failure.

Measures in MO2 would cause notable changes in outflow from Libby in almost every season; however, changes would be most evident during winter as a result of the *December Libby Target Elevation* measure. Average monthly outflows would change from an approximately 30 percent increase in the late summer, fall, and winter (i.e., June through September, November and December) to an approximately 10 to 40 percent decrease in the late winter and early spring (i.e., January, February, and March). Releases in April and May would be approximately 5 to 25 percent lower to support aggressive refill according to the *Modified Draft at Libby* measure. In mid-May, outflow would increase in all but the driest years. Overall, these changes would decrease the spring freshet, which supports vegetation and wildlife in the Kootenai River.

In the free-flowing reach of the Kootenai River between Libby and Bonners Ferry, water levels (compared to the No Action Alternative) could be up to several feet higher in the early winter and occasionally over a foot lower during the rest of the year. Minor changes are expected downstream of Bonners Ferry. As a result of higher winter flows, the banks of the Kootenai River would be inundated, and any riparian seeds and seedlings deposited during the summer months could be carried downstream as flows recede in January. Lower spring freshets would reduce the deposition of riparian seeds onto the riverbanks and lower the likelihood of cottonwood establishment and recovery of these forests. Higher winter flows and increased water levels would freeze the shorelines and increase the likelihood of bank sloughing and erosion in the winter months, leading to degraded water quality. Because these measures at Libby would result in higher winter flows and lower spring flows, the current trend of declining quantity and quality of deciduous plant communities and conversion to coniferous uplands would slightly accelerate under MO2 (KTOI 2013). Wildlife populations dependent upon forested and scrub-shrub wetland habitats would be reduced under MO2. The effect would be major, without mitigation, over the long term as these habitats could eventually be eliminated. Through the F&W Program, Bonneville has funded the KTOI to manage and implement large-scale habitat restoration measures within the Kootenai River. These habitat restoration actions have increased the active floodplain and work to restore riparian forest habitat, including efforts to restore black cottonwood galleries.

Operational changes at Hungry Horse to maximize hydropower generation (Ramping Rates for Safety and Slightly Deeper Draft for Hydropower) would result in lower pool elevations during winter and spring months (i.e., January through June) compared to the No Action Alternative. The reservoir would be drafted in January and would be approximately 8 feet lower compared to No Action Alternative conditions through May in average years. In dry years, the reservoir would be drafted even more to maintain hydropower generation. There would be no change to late summer conditions on the reservoir. The full pool elevation would not change under MO2 and this water surface elevation would be reached during the growing season in July. The primary habitat types affected by these changes would be the barren zone and emergent herbaceous and forested and scrub-shrub wetland habitats adjacent to the reservoir. In most years, deeper drafts would result in a wider barren zone. As a result, the barren zone would expand this area by approximately 5 vertical feet compared to the No Action Alternative, increasing the area of exposed ground that could be colonized by non-native invasive plants.

Despite maintaining current wildlife habitats, wildlife surrounding both Libby and Hungry Horse Reservoir would experience an increased risk of predation when the reservoir is drawdown in the early part of the growing season due to increased exposure to predators, similar to other alternatives. The *Ramping Rates for Safety* measure and decreased water levels during the winter months (from the *Slightly Deeper Draft for Hydropower* measure to increase hydropower generation) could result in effects to riparian vegetation on the South Fork Flathead River downstream. These effects would likely be minor due to the confined and generally rocky nature of the South Fork River below the dam, and due to transmission limitations that already limit generation benefits that less restrictive ramping rate are intended to benefit.

Downstream of Hungry Horse, water levels on the South Fork Flathead and mainstem Flathead Rivers would increase from operations to increase hydropower generation. These operations would raise water levels at Columbia Falls by approximately 1 to 1.5 feet in January. This increase in water levels would be followed by slightly lower water levels (less than 0.5 foot) in the early part of the growing season between March and June. For the remainder of the year, water levels at and downstream of Columbia Falls would be consistent with No Action Alternative conditions.

As a result of higher winter flows, the banks of the Flathead River would be inundated, and any riparian seeds and seedlings deposited during the summer months would be carried downstream as flows recede in January. Lower spring freshets would reduce the deposition of riparian seeds onto the riverbanks and lower the likelihood of cottonwood establishment and recovery of these forests. Higher water levels in the channel would freeze shorelines that are above ordinary high water under the No Action Alternative, which would increase the likelihood of bank sloughing and erosion, leading to degraded water quality. Because these measures at Hungry Horse would result in higher winter flows and lower spring flows, there could be a shift to vegetation communities more tolerant of dry conditions under MO2. Wildlife populations dependent upon forested and scrub-shrub wetland habitats could be reduced under MO2.

Operational changes at Hungry Horse would influence the Pend Oreille Basin, but with increasingly diluted effects closer to Albeni Falls as tributary inputs provide inflow to the river. The operational changes at Hungry Horse would increase Lake Pend Oreille water levels during the winter and spring by approximately 0.5 foot and decrease water levels by approximately 0.5 foot between March and May.

Implementing the *Ramping Rates for Safety* measure at Hungry Horse would influence flow conditions and water surface elevations at Albeni Falls. However, changes resulting from implementation of this measure would result in negligible effects on the quantity, quality, or distribution of wildlife habitats or populations in the Albeni Falls study area. The discussion below focuses on the potential effects of implementing MO2 operations at Albeni Falls.

Habitats most likely to be affected by the fluctuating water levels would be mudflats and barren zones, emergent herbaceous and forested and scrub-shrub wetlands, submerged aquatic beds, and islands. Implementing MO2 would increase the repeated exposure of mudflats and barren lands compared to the No Action Alternative, exposing these areas to increased rates of erosion from boat wakes, wind, and waves. Wildlife species most likely to be affected include waterfowl, shorebirds, beaver, muskrats, amphibians, and insects.

Under MO2, changing ramping rates and draft conditions at Albeni Falls would change water surface elevations on Lake Pend Oreille and the Pend Oreille River downstream of the dam. These changes would result in increased desiccation of submerged aquatic vegetation and emergent wetland plants, which could lead to decreased productivity and changes to plant composition in wetland habitats over time. These changes would be paralleled by wildlife dependent on wetland habitats, including amphibians and insects. Similarly, the quantity, quality, and distribution of wetland vegetation would change if ramping rates result in lower water elevations. Under these conditions, emergent herbaceous and forested and scrub-shrub wetland vegetation occurring adjacent to the shoreline would be disconnected hydrologically from the river under MO2. Decreasing hydrologic connectivity of wetland habitats would lead to an overall reduction in productivity and a shift in the composition of plant species to those more tolerant of dry or drought conditions. Downstream of the dam changes in ramping could alter patterns of seed dispersal, germination, and establishment, and the long-term viability of emergent herbaceous and forested and shrub-scrub wetlands along the shoreline.

The shifting water levels on the Pend Oreille River would impact a variety of aquatic and terrestrial wildlife immediately downstream of Albeni Falls Dam, such as beaver and muskrats, amphibians, and waterfowl. If beaver lodges or other mammal dens are temporarily isolated from the shoreline as water levels drop relative to No Action Alternative conditions, these locations would be unsuitable for wildlife. Changes in water surface elevations on Lake Pend Oreille, particularly in Denton Slough during the nesting season, would alter the availability of vegetation and suitable nesting habitat for western grebe. If water levels drop rapidly or lower than No Action Alternative conditions, nests could dislodge, tip, and break apart, which would result in mortality of eggs or young. Rapid ramping rates would expose nests to increased risk of predation and failure, especially if nests are dislodged and pulled out of the slough where they would be exposed to recreational boat traffic and weather.

Under MO2, a reduction in water levels from ramping rates and a deeper drawdown would decrease the quality of off-channel habitat for wildlife by increasing the distance between suitable nesting habitat and the water. Reducing the quantity and quality of off-channel habitat available in sloughs and bays would force waterfowl, amphibians, and reptiles like turtles to relocate to areas closer to the main reservoir where the risk of exposure to boats, high winds, and waves is greater (Hull 2019). While migratory birds would be adversely affected by reduction in the quantity and quality of wetland habitats from altered patterns of exposure and inundation, shorebirds would benefit from increased quantity of foraging habitat on exposed mudflats during the spring and summer breeding season.

The operational changes at Region A from MO2 would also be evident in downstream reaches of the Columbia River, as discussed in the Regions B and D sections below. In regard to potential effects in Canada, the effects to vegetation and wildlife resources and their habitats under MO2 are expected to be similar to the effects described for the United States portion of Region A.

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

No structural measures would be implemented in Region B as part of MO2. Six operational measures would be implemented in Region B, which differ from current operations as described under the No Action Alternative: the *Ramping Rates for Safety*, *Slightly Deeper Draft for Hydropower*, *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, *Grand Coulee Maintenance Operations*, and *Winter System FRM Space* measures. Collectively, these measures increase operational flexibility to maximize hydropower generation by altering draft and refill procedures while balancing FRM, and allowing for slightly deeper and earlier drafts during larger forecast years.

Overall, Lake Roosevelt would have lower winter water levels compared to the No Action Alternative during drawdown due to the change in draft rates associated with the *Planned Draft Rate at Grand Coulee* and *Slightly Deeper Draft for Hydropower* measures. Implementing MO2 would result in deeper drafts for hydropower, which would decrease water surface elevations in Lake Roosevelt by approximately 3 to 6 feet during the winter months. Because the measures would be implemented during the winter months, there would be negligible changes to habitats during the growing season, and as a result, there would be no change to the quantity, quality, and distribution of wildlife habitat in the study area.

Similar to MO1, changes to water surface elevations or fluctuating water conditions in Lake Roosevelt could impact the quantity and quality of foraging habitat for wintering waterfowl. Decreasing pool elevations would decrease the quantity and suitability of open water habitat and decrease access to emergent or submerged aquatic vegetation in shallow-water areas for loon and other waterfowl foraging on the reservoir. Unlike MO1, lower lake levels would not persist into the growing season and effects to waterfowl would be limited to winter forage habitat. By spring, water surface elevations in Lake Roosevelt would be consistent with No Action Alternative conditions.

Lower winter lake elevations would impact predator-prey relationships along the shoreline of the reservoir and on portions of the lake itself. Because water levels would be lower, bighorn sheep populations, specifically, would be adversely affected as a result of increased exposure to predation from mountain lion (Wood 2019). Conversely, deer and other ungulates would benefit from lower reservoir elevations and corresponding decrease in wolf predations.

Any changes in water levels at the upstream ends of Chief Joseph Reservoir and the other projects through the middle Columbia reach (Wells Dam, Priest Rapids, etc.) would occur as a result of the changes in outflow from Grand Coulee associated with the *Ramping Rates for Safety* measure. Flow conditions and water levels would generally increase in December as a result of the *Winter System FRM Space* measure and decrease between February and September. Both the increase in winter water levels and the decrease in spring and summer would be less than 0.5 foot compared to No Action Alternative conditions and these changes would be most evident in the free-flowing Hanford Reach downstream of Priest Rapids Dam. Changes less than 0.5 foot would be difficult to measure and are assumed to be consistent with natural variation and fluctuations in water levels resulting from daily operations. Changes in the annual average probability of inundation from current conditions would be negligible. Therefore, this measure would have no effect on the quantity, quality, or distribution of wildlife habitats or populations in Grand Coulee study area and would have negligible effects on floodplain function.

The effects of implementing operational changes at Grand Coulee under MO2 would be evident throughout the lower Columbia River, as discussed below for Region D. Specifically, the *Planned Draft Rate at Grand Coulee* and *Winter System FRM Space* measures would influence water levels upriver of McNary Dam (i.e., the Hanford Reach). In regard to potential effects in Canada, the effects to vegetation and wildlife resources and their habitats under MO2 are expected to be similar to the effects described for the United States portion of Region B.

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

The following structural measures would be implemented as part of MO2 in Region C: the *Additional Powerhouse Surface Passage*, *Fewer Fish Screens*, *Upgrade to Adjustable Spillway Weirs*, *Lower Snake Ladder Pumps*, *Turbine Strainer Lamprey Exclusion*, *Bypass Screen Modifications for Lamprey*, and *Lamprey Passage Ladder Modifications* measures. Collectively, these measures increase downstream survival of juvenile salmon, steelhead, and lamprey, and improve upstream passage conditions for adult salmon, steelhead, and lamprey. These structural measures are limited to the immediate vicinity of the project dams on the lower Snake River and construction-related effects would not result in widespread effects to wildlife habitats or populations in the Region C study area.

The following operational measures would be implemented as part of MO2 in Region C: the Spill to 110 percent TDG, *Ramping Rates for Safety*, *Full Range Reservoir Operations*, *Slightly Deeper Draft for Hydropower*, *Full Range Turbine Operations*, *Increase Juvenile Fish Transportation*, *Contingency Reserves During Fish Passage Spill*, *Winter System FRM Space*, and *Zero Generation Operations* measures. Collectively, these measures would increase the generation of affordable, non-fossil fuel energy sources through increased hydropower production and increased integration of non-hydropower renewable power sources such as wind and solar; increase flexibility to raise and lower flows and increase the ability for hydropower to meet fluctuations in demand; increase juvenile fish transportation; alter draft and refill procedures to increase hydropower generation while balancing FRM; allow more water to pass thorough the turbines and thereby reduce the incidence of high TDG levels; and adjust winter pool elevation targets.

Dworshak Dam would be drafted for hydropower generation, and reservoir elevations would decrease by approximately 2.5 to 30 feet January through April, decrease by approximately 10 feet in May and June, and recover to essentially the same elevation as the No Action Alternative by the end of July. Despite the magnitude of change compared to the No Action

Alternative, implementing MO2 in the Dworshak study area would be consistent with the effects analysis described above for Albeni Falls in Region A. Implementing the measures associated with MO2 would result in changes to water levels, impacting barren zones and mudflats, emergent herbaceous and forested and scrub-shrub wetlands, and submerged aquatic beds. Fluctuations in pool elevations would decrease hydrologic connectivity to floodplains and emergent herbaceous and forested and scrub-shrub wetlands, which would lead to desiccation of plants or a shift in plant composition to species more tolerant of dry or drought conditions.

Wildlife affected by these changes would include waterfowl, shorebirds, amphibians, and insects. In response to changing foraging conditions in emergent herbaceous wetlands and shallow- and open-water habitats, waterfowl and shorebirds would relocate to areas with suitable foraging habitat.

In addition, as a result of the *Slightly Deeper Draft for Hydropower* measure, water levels in the Clearwater River would be approximately 1 foot higher in January when compared to the No Action Alternative. Minor increases in the annual average probability of inundation would occur, with minor effects on floodplain benefits. The more exposed shoreline conditions during the growing season would dry wetland habitats.

On the Clearwater River, changes in water levels resulting from the *Ramping Rates for Safety* measure would desiccate emergent herbaceous and forested and scrub-shrub wetland habitats. Longer prolonged drying from the *Slightly Deeper Draft for Hydropower* measure would encourage the plant species composition in these habitats to transition to species more tolerant of dry or drought conditions and a portion of wetland habitats may transition to upland habitat. Downstream of Dworshak, changes in outflows associated with hydropower generation would alter the patterns of seed dispersal, germination, and establishment of forested and scrub-shrub wetland plants like willows or cottonwoods. Depending on the level of change, this measure could impact the long-term viability of wetland habitats along the shorelines of the Clearwater River.

Under MO2, the reservoir elevations at the four lower Snake River dams would differ from those of the No Action Alternative due to the full *Range Reservoir Operations* measure, which calls for operating within the full reservoir operating range throughout the year, instead of reducing the normal operating range in the MOP season, April through August. Lower Granite Dam and Little Goose Dam reservoir would increase approximately 4.0 feet higher during high water events in April through August compared to the No Action Alternative. Lower Monumental Dam and Ice Harbor reservoir would operate approximately 2 foot higher than the No Action Alternative.

This measure would therefore increase the quantity, quality, and distribution of wetland habitats in the Lower Snake River. Emergent herbaceous wetland may become established in new areas where the water depth and inundation patterns support establishment of wetland vegetation and soil conditions. Scrub-shrub and forested wetlands adjacent to the shoreline may convert to emergent because of this prolonged inundation. This effect would be minor.

There would be a conversion in the quality and distribution of existing emergent herbaceous and forested and scrub-shrub wetlands under MO2 when compared to the No action Alternative. Existing wetlands would continue to be productive habitats, supporting breeding amphibians, reptiles, mammals, and birds during spring and summer breeding season. As a result, there would be some effects to wildlife populations using these habitats. For example, the overall quantity and quality of habitat for ground-nesting birds, such as the harlequin duck that breed along well-concealed streambanks or on islands between Silcott Island and Ice Harbor, would increase. Additionally, if some woody vegetation transitions to emergent vegetation over time, the amount of nesting habitat for birds such as veery or warblers that nest in wetland thickets may decrease. In these circumstances, birds may be forced to relocate to other areas where suitable nesting habitat is available, which could increase competition for limited resources. As a result, the overall distribution in quantity of invasive species in Region C would remain similar to the No Action Alternative. Where no management efforts are implemented, invasive species are expected to persist under MO1 similar to the No Action Alternative.

Similar to the fish transport measures included in MO1 and MO4, the *Increase Juvenile Fish Transportation* measure would decrease the quantity of juvenile salmon and steelhead available to avian and mammalian predators in the lower Snake River between April 25 and August 31. Decreasing the number of juveniles in the lower Snake River study area would decrease overall prey resources supporting a variety of wildlife populations at higher trophic levels (e.g., colonial nesting waterbirds, waterfowl, and otter). Wildlife populations in the lower Snake River that are dependent on juvenile salmonids as a prey source would transition to other resources, or populations may relocate to other areas where prey resources are more widely available. However, the results of the fish modeling analysis in Section 3.5 indicate fish would move through the system more slowly and survival for juvenile salmon and steelhead that migrate in-river would be lower than under the No Action Alternative.

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

Structural measures associated with MO2 in Region D would include the *Lamprey Passage Structures*, *Turbine Strainer Lamprey Exclusion*, and *Lamprey Passage Ladder Modifications* measures. These measures would collectively increase downstream survival of juvenile lamprey and improve upstream passage conditions for adult lamprey. These structural measures would be limited to the immediate vicinity of the project dams on the lower Columbia River and construction-related effects would not result in widespread effects to wildlife habitats or populations.

Under MO2, there would be no change to the reservoir elevations at McNary, The Dalles, Dam, or Bonneville Dam. At John Day Dam, the *John Day Full Pool* measure calls for operating the reservoir in a range that goes up to 266.5 feet NGVD29 year round, except as needed for FRM. When operation is needed for FRM, the full operating range (257.0 to 268.0 feet NGVD29) may be used, as is the case for the No Action Alternative. Pool elevations would be between 1.5 foot higher than the No Action Alternative from March 15 to April 9 and increase by 2.5 feet higher than the No Action Alternative from April 10 to September 30. Consequently, floodplains, aquatic, or terrestrial habitats and wildlife populations in the John Day study area would be moderately impacted by the changes of implementing MO2.

Operational measures associated with MO2 in Region D also include the *Ramping Rates for Safety*, *John Day Full Pool*, and *Increase Juvenile Fish Transportation* measures. Collectively, these measures would influence operations in Region D and decrease downstream survival of juvenile salmon and steelhead, entering the estuary, decreasing the survival and return of adult salmon and steelhead, and increasing flexibility for hydropower generation.

Changes to water surface elevations and the average probability of inundation in the McNary, The Dalles, and Bonneville Dam study areas would be negligible and within the natural range of variability, so minor impacts to floodplains are expected (see additional information below). As a result, the quantity, quality, and distribution of habitat would be moderately wetter than No Action Alternative conditions. Burbank Slough and McNary NWR would not experience changes in water levels or flow conditions, and habitats would remain consistent with No Action Alternative conditions.

As a result, the quantity, quality, and distribution of habitat would not change measurably from No Action Alternative conditions and there would be no corresponding changes to wildlife populations. Existing wetlands would continue to be productive habitats, supporting breeding amphibians, reptiles, mammals, and birds during the spring and summer breeding season. These wetland habitats would continue to support regionally important migratory waterfowl overwintering in the Umatilla NWR IBA by providing forage opportunities and prey resources.

Minor reductions in flood elevations would occur below Bonneville Dam for floods that occur with moderate to low frequency, which could have minor effects on floodplain benefits in this region. On average, changes in river levels downstream of Bonneville Dam would be within the natural range of variability in daily water levels. For this reason, MO2 is not expected to cause measurable effects to wildlife populations or their habitats downstream of Bonneville Dam. The lower portions of the Columbia River would continue to support valuable habitat for fish and wildlife, and current trends are expected to continue.

Similar to the juvenile fish transport measures included in MO1 and MO4, the *Increase Juvenile Fish Transportation* measure included in MO2 and detailed in the Region C section above would decrease the quantity of juvenile salmon and steelhead available to avian and mammalian predators between the lower Snake River and Bonneville Dam between April 25 and August 31. Decreasing the number of juveniles in the John Day, The Dalles, and Bonneville Dam study areas would decrease overall prey resources supporting a variety of wildlife populations at higher trophic levels, specifically colonial nesting terns, gulls, and pelicans in Lake Wallula and Lake Umatilla. These colonies prey heavily on juvenile salmonids and fewer fish would likely force birds to transition to other prey resources or relocate breeding activities to other areas on the Columbia Plateau where prey resources are more widely available. Depending on the availability of nesting habitat, this has the potential of causing a decline in predatory avian bird populations or shifting the predation problem elsewhere in the Columbia Plateau.

**FLOODPLAINS**

Under MO2, changes in flood elevations would typically be negligible (absolute value less than 0.3 foot) across the Columbia River Basin for all flood frequencies, from regularly occurring floods (AEP of 50 percent) to the base flood (AEP of 1 percent). Minor reductions in flood elevations (absolute value less than 1 foot) are predicted in Region D for the Columbia River below Bonneville Dam for floods with moderate to low frequencies (AEP values from 15 to 2 percent). Based on these results, the annual average probability of inundation would remain unchanged from current conditions in most of the basin, with minor reductions in inundation frequency below Bonneville Dam. These changes could have minor effects on floodplain benefits in this region.

**SPECIAL STATUS SPECIES**

Table 3-104 provides details about ESA-listed wildlife species that are known or likely to occur in the study area and potential effects to these species or their critical habitats in response to implementation of MO2. Similar to the No Action Alternative, it is assumed that federally listed species present in the study area would remain listed and existing regulatory and best management practices would reduce the likelihood that populations would continue declining or go extinct. It is assumed that neither grizzly bear critical habitat nor whitebark pine would be listed and their presence and population in, or in the vicinity of, the study area would remain relatively stable.

As described in Section 3.5, the fish models predict differing levels of SARs under MO2 in comparison to the No Action Alternative. The CSS model predicts a reduction in SARs, while the LCM predicts a small increase due to the increase in the number of fish that will be transported under the *Spill to 110 Percent TDG* and the *Increase Juvenile Fish Transportation* measures. Under the CSS model predictions these changes in the overall abundance of adult salmon and steelhead would decrease the prey base available to marine mammals foraging in the Columbia River, such as seal or sea lion, or offshore from the mouth of the Columbia River, such as killer whale. Under the LCM model predictions, the small increase in SARs would increase the prey base to marine mammals foraging in the Columbia River or offshore from the mouth of the Columbia River. However, under either the CSS or LCM models, the overall effect would be 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 | *Ursus arctos horribilis* | ESA status: T<br>CH: proposed | Libby<br>Hungry Horse | **Construction of structures on the dam:** No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected.<br>**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.<br>**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 | *Odocoileus virginianus leucurus* | ESA status: T<br>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.<br>**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.<br>**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 | *Zalophus californianus* | ESA status: None<br>CH: None<br>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.<br>**Prey availability:** Negligible effect. Prey availability would be slightly less.<br>**Conclusion:** Negligible effect. Hazing would continue similar to the NAA. Overall population of California sea lions would remain stable. |
| Steller sea lion | *Eumetopias jubatus* | ESA status: None<br>CH: None<br>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.<br>**Prey availability:** Negligible effect. Prey would be slightly less. Hazing would continue similar to NAA.<br>**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 | *Orcinus orca* | ESA status: E<br>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.<br>**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.<br>**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 | *Coccyzus americanus* | ESA status: T<br>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.<br>**Hydrology:** Negligible effect to suitable habitat. Water fluctuations at Libby would result in high winter flows that could prevent establishment of cottonwoods galleries.<br>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.<br>**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 | *Eremophila alpestris strigata* | ESA status: T<br>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.<br>**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.<br>**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 | *Haliaeetus leucocephalus*<br>*Aquila chrysaetos* | ESA status: none<br>CH: none<br>Bald and Golden Eagle Protection Act | Throughout the study area. | **Construction of structures on the dam:** Negligible effect.<br>**Hydrology:** Negligible effect. MO2 operations would reverse trends in reducing riparian habitat along the Kootenai River. Bald eagle would nest in mature cottonwood trees.<br>**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 | *Spiranthes diluvialis* | ESA status: T<br>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.<br>**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.<br>**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. |

Note: C = Candidate for listing; CH = Designated Critical Habitat; E = Endangered; T = Threatened.

**SUMMARY OF EFFECTS**

Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue, including protection, mitigation, and enhancement of wildlife habitat as discussed in Section 5.2.1. The effect of MO2 could be summarized by region as follows:

In Region A, the Lake Koocanusa barren zone would expand by approximately 5 feet compared to the No Action Alternative, increasing the area of exposed ground that could be colonized by native or non-native invasive plants. A wider barren zone would provide an increased area of barren zone where small mammals would be more vulnerable to predation and where flowering rush may establish. Measures in MO2 would cause notable changes in outflow from Libby Dam in almost every season, resulting in a decrease in the spring freshet, which supports vegetation and wildlife in the Kootenai River. Because these measures at Libby would result in higher winter flows and lower spring flows, there could be a decline in the quantity and quality of deciduous plant communities and conversion to coniferous uplands under MO2 compared to the No Action Alternative. Wildlife populations dependent upon forested and scrub-shrub wetland habitats could also be reduced under MO2. MO2 operations would support exposure of island habitats and development of associated nesting habitat in the spring and summer in these areas. Deeper Hungry Horse barren zones would alter wetland habitat types and result in increased barren areas. The higher winter flows and lower spring flows could result in a shift in downstream vegetation communities and associated wildlife communities. The areas in the Pend Oreille River near Albeni Falls Dam would experience a similar shift in vegetation, wildlife habitat, and wildlife communities. Additionally, the annual average probability of inundation would remain unchanged from current conditions in Region A, resulting in minor effects on floodplain benefits in this region. Overall, the effects from MO2 on vegetation and wetlands would be moderate, while effects to wildlife could be major.

In Region B, decreasing pool elevations would decrease the quantity and suitability of open water habitat and decrease access to emergent or submerged aquatic vegetation in shallow-water areas for loon and other waterfowl foraging on the reservoir resulting in minor effects to waterfowl. These lower lake levels would not persist into the vegetation growing season and would have negligible impact on plant communities. Lower pool elevation in winter could result in potentially higher predation on wildlife species such as bighorn sheep. This would be a minor adverse effect for prey, such as ungulates. The quantity, quality, or distribution of wildlife habitats and populations for areas in Region B outside of the Lake Roosevelt area would not change from the No Action Alternative. Annual average probability of inundation would remain unchanged from current conditions in Region B. Overall, MO2 would have a minor effect to vegetation, wetlands, habitat, and wildlife in Lake Roosevelt. MO2 would have a negligible effect on these resources in the other locations in Region B.

In Region C, changes in Dworshak reservoir water levels and river levels downstream of Dworshak would increase the timing and extent of the barren zones and mudflats, emergent herbaceous and forested and scrub-shrub wetlands, and submerged aquatic beds. Decreased hydrologic connectivity to emergent herbaceous and forested and scrub-shrub wetlands would lead to drying out of plants or a shift in plant composition to species more tolerant of dry or drought conditions. Changes in outflows associated with hydropower generation would alter the patterns of seed dispersal, germination, and establishment of forested and scrub-shrub wetland plants like willows or cottonwoods. Implementing MO2 would not result in measurable changes to water levels on the lower Snake River, and as a result, there would be no change to floodplain function or quantity, quality, or distribution of wildlife habitats in the lower Snake River study area. Increases in salmon transport in the area may result in increased prey base for wildlife. Overall, the effects from MO2 on vegetation, wetlands, wildlife, and habitat in Region C would be negligible.

In Region D, the quantity, quality, and distribution of habitat would not change measurably from No Action Alternative and there would be no corresponding changes to wildlife populations. A reduction in the wetland habitats immediately downstream of Bonneville Dam could reduce wetland quantities and adversely impact the pond turtle, further threatening the viability of the regional population, but there would be little effect past Bonneville Dam in the lower Columbia River. Changes in prey base may result in wildlife and birds switching to other prey sources or relocating to alternate locations, which would result in minor impacts to these populations. Additionally, minor reductions in inundation frequency would occur below Bonneville Dam, resulting in minor effects on floodplain benefits in this region. Overall, the effects from MO2 on vegetation, wetlands, wildlife, and habitat in Region D would be negligible.

For special status species in all regions, multiple special status species would be impacted by MO2 beyond No Action Alternative conditions. Overall, there would be a negligible impact on most special status species.

#### *3.6.3.5 Multiple Objective Alternative 3*

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

No structural measures would be implemented in Region A under MO3 and, therefore, the proposed structural measures would not impact wetlands or wildlife habitats or populations.

Under MO3, operational measures influencing Region A are the *Ramping Rates for Safety*, *Sliding Scale at Libby and Hungry Horse*, *Modified Draft at Libby*, *December Libby Target Elevation*, and *Hungry Horse Additional Water Supply* measures. Collectively, these measures would influence operations in Region A by altering ramping rates, as well as draft and refill procedures at Libby and Hungry Horse Dams, and modifying winter draft targets and summer drafting (similar to measures proposed under MO1). Operations would change as a result of implementing the *Ramping Rates for Safety* measure. In comparison with the No Action Alternative, implementing the *Ramping Rates for Safety* would permit greater flexibility in flows to allow water to be shaped (within-day) for hydropower production to meet demand. The *Hungry Horse Additional Water Supply* measure would reduce flows and have a minor influence (decrease) on WSE at Lake Pend Oreille and downstream of Albeni Dam.

Under MO3, water surface elevations on Lake Koocanusa would be decreased in winter and spring, and increased in late summer, compared to the No Action Alternative. November and December reservoir elevations would be 7 to 11 feet lower in most years due to implementing the *December Libby Target Elevation* measure. The *Modified Draft at Libby* measure would implement a deeper draft in dry years, resulting in pool elevations that would be as much as 25 feet lower from December through April when compared to the No Action Alternative. Reservoir elevations would increase by approximately 0.5 foot in the late summer from implementing the *Sliding Scale at Libby and Hungry Horse* measure.

The primary habitat type affected by these changes is the barren zone, and emergent herbaceous and forested and scrub-shrub wetland habitats adjacent to the reservoir. In most years, deeper drafts would result in a wider barren zone. As a result, the barren zone would expand this area by approximately 5 feet compared to the No Action Alternative, increasing the area of exposed ground that would be colonized by native or non-native, invasive plants.

The *Ramping Rates for Safety* measure has the potential to change the timing, speed or rate, and frequency of hydropower generation within a given day in Region A. Because hydropower generation influences pool elevations and river conditions downstream of project dams, it is anticipated that changing ramping rates for hydropower generation would result in effects to vegetation and wildlife. While the hourly or daily operational changes cannot be detected in modeling conducted for this analysis, it is assumed that an increase in fluctuations throughout the year could influence the quantity, quality or condition, and distribution of shoreline habitats. Changing water levels and altering patterns of inundation and seasonal drying have the potential to drown out vegetation, which would influence growth and establishment of plant communities and wildlife habitats.

Lower water levels in the spring and early summer would reduce productivity in existing emergent herbaceous and forested and scrub-shrub wetlands where they occur at the mouths of tributaries, like the Tobacco River. If habitats become disconnected from water sources or current patterns of inundation change, plant growth and survival would decline, which would further result in unproductive or non-functioning habitats (DeBerry and Perry 2019). Furthermore, because pool elevations would be lower for the majority of the growing season, wetland habitats could transition into upland habitats or plant communities. For example, tree and shrub species like willows (*Salix* spp.) and cottonwoods (*Poplar* spp.) would dry out and the type of trees and shrubs would shift to species more tolerant of dry or drought conditions. A widespread dieback of emergent vegetation would lead to a temporary increase in vegetative decay and a subsequent decrease in dissolved oxygen, which would affect benthic invertebrates and the overall food web. If changes to pool elevations were abrupt, it would impact the quality and quantity of nesting habitat for waterfowl in the spring and summer. As water levels rise in summer by 0.5 to 5 feet from No Action Alternative, waterfowl nests attached to aquatic vegetation or connected to the shoreline may be submerged, and affect waterfowl like western grebe (*Aechmophorus occidentalis*), mallard (*Anas platyrhynchos*), American coot (*Fulica americana*), northern shoveler (*Spatula clypeata*), and cinnamon teal (*Spatula cyanoptera*).

There are few islands in Lake Koocanusa under the No Action Alternative for nesting waterbirds; however, MO3 operations would support exposure of island habitats and development of nesting habitat in the spring and summer, similar to MO2.

H&H modeling results indicate outflows would increase in the early winter (November and December) by approximately 10 to 35 percent and decrease for the remainder of the year by 5 to 40 percent under MO3. As a result, water levels on the Kootenai River would be 0.5 to 2 feet higher in the early winter and 0.5 to 3 feet lower the rest of the year compared to No Action Alternative conditions. These changes would be most evident in the river from Libby Dam downstream to near Bonners Ferry, and would become less measurable below Bonners Ferry as water levels are largely controlled by Kootenai Lake elevations in Canada.

As a result of these changes in outflow and subsequent water levels on the Kootenai River, implementing MO3 would increase water levels near Bonners Ferry, Idaho, in the winter. As discussed above, high winter flows would inundate riverbanks and redistribute seeds from forested wetland vegetation. Higher water levels in the winter would increase bank sloughing and erosion, potentially degrading water quality for aquatic wildlife. Furthermore, lower spring flows would reduce moisture content of soils, which would reduce the suitability of shoreline habitat in the spring and summer for seed deposition and plant establishment. Consequently, existing trends of diminishing deciduous tree cover, specifically cottonwood galleries and poor recruitment of saplings, would continue and would increase from No Action Alternative conditions (KTOI 2013). Large black cottonwood (*Populus trichocarpa*) trees along the banks of the Kootenai River respond to additional inundation in the winter or an increase in dry conditions in the spring, causing flood or drought response within a forest stand, which can impact health and growth of the forest stand. Through the F&W Program, Bonneville has funded the KTOI to manage and implement large-scale habitat restoration measures within the Kootenai River. These habitat restoration actions have increased active floodplain and work to restore riparian forest habitat, including efforts to restore black cottonwood galleries.

Potential changes to water levels would influence management areas and refuge habitats, like the Kootenai Falls Wildlife Management Area near RM 202. Changing water levels have the potential to inundate and dry out narrow bands of emergent vegetation along the shoreline of management areas. These changes would have little effects to upland species, like mule deer, bighorn sheep, and white-tailed deer, but would alter the quantity and quality of wetland habitat types that are receiving flows from the Kootenai River (KTOI 2013).

Because water levels would be approximately 0.5 to 2 feet lower in the spring and summer months, streamside thickets and wetland habitats could transition to plant communities more tolerant of dry or drought conditions. These changes would reduce nesting habitat for migrant songbirds, including veery (*Catharus fuscescens*), yellow warbler (*Setophaga petechia*), and common yellowthroat (*Geothlypis trichas*). Localized declines in forest health would reduce the availability of nesting habitat for raptors and waterbirds, which nest in forested wetlands during the breeding season. For example, if younger trees do not replace mature trees, nesting habitat for nesting bald eagles and great blue heron rookeries would decline.

Lower spring and summer river conditions on the Kootenai River would dry off-channel sloughs and backwater habitats from May to late June, desiccating immotile amphibian eggs like those of the western toad (*Anaxyrus boreas*). If egg masses are desiccated and toads are unable to successfully breed in subsequent years, the effects of changing river conditions would lead to interruptions in the life cycle of this species. The northern leopard frog (*Lithobates pipiens*) would also decline if backwater habitats dry earlier in the season. The loss of thin-stemmed emergent vegetation would reduce the availability of egg-laying habitat required by the species.

Aquatic invertebrates, like caddisflies and stoneflies, would experience minor interruptions in life cycle, which would disrupt food availability throughout the ecosystem. These macrobenthics would desiccate during times of drawdown and with more frequency and duration than under the No Action Alternative. Perching birds and bats dependent upon springtime emergence of aquatic insects would experience declines in reproductive success if invertebrate prey resources were not available in sufficient quantity to support breeding individuals. Bats common in the Kootenai River basin, like little brown bat (*Myotis lucifugus*) and Yuma myotis (*M. yumanensis*), may have difficulty feeding after emergence from winter torpor.

At Hungry Horse Dam, the effects to vegetation, wetlands, and wildlife in the vicinity of the reservoir and along the South Fork Flathead and Flathead Rivers downstream of the dam, would be the same as those described under MO1, with the exception of the relaxation of ramping rates (*Ramping Rates for Safety*). This measure would increase and decrease flows in the South Fork Flathead River based on hydropower demand, rapidly inundating or exposing the streambank. This would not impact vegetation as flows would be within the operational range for the South Fork Flathead and mainstem Flathead Rivers and would be at or below high flows, which occur in the spring and early summer. A decrease of a few hundred cubic feet per second in spring represents a fraction of high flows and would be negligible. The banks along the South Fork Flathead River are well armored and vegetated, and any rapid change in flow would not alter vegetation along the reach. There would not be an effect in the Flathead River as any change in flow would be negligible and diluted by the North Flathead and Middle Fork Flathead flows. See Section 3.6.3.3 for greater details on potential effects in the Hungry Horse study area.

Under MO3, implementation of the *Hungry Horse Additional Water Supply* measure would reduce flows on the Flathead, Clark Fork, and Pend Oreille Rivers in the winter and spring, and would have negligible effect on water surface elevations in Lake Pend Oreille and downstream of Albeni Falls Dam in order to provide the additional 90 kaf of water for use in the region above Flathead Lake. The effects of this measure and the resulting changes in flow would be water levels typically a few inches lower in the winter and spring in transitional and free flowing reaches. Despite these changes, the *Hungry Horse Additional Water Supply* measure would not influence the quantity, quality, or distribution of aquatic or wetland vegetation adjacent to the reservoir or river. As a result, the *Hungry Horse Additional Water Supply* measure would not influence wildlife habitats or populations in Albeni Falls study area.

Similar to the discussion about the potential effects from changing ramping rates at Libby Dam, implementing MO3 at Albeni Falls Dam would result in potential effects to floodplains, vegetation, and wildlife. Water surface elevations and river conditions influence patterns of seed dispersal, plant establishment, vigor, and growth. Changing the pattern, timing or frequency of inundation as a result of increasing flexibility with ramping rates under MO3, would affect habitat quality and succession in the Albeni Falls study area. As a result, these changes would influence the quantity, quality, and distribution of aquatic and terrestrial habitats, and the suitability of these habitats for wildlife (Bejarano, Jansson, and Nilsson 2017), to an unknown degree.

Changing ramping rates would affect mudflats, emergent wetlands, and marshes. These habitats would dry out more frequently and for longer durations compared to the No Action Alternative. As a result, invertebrate and amphibian populations would be the most vulnerable to this measure (International Finance Corporation, World Bank Group 2018). If water surface elevations decrease quickly, aquatic macroinvertebrates could be stranded on exposed sediments resulting in desiccation or predation. As a result, changing the patterns of inundation in these areas would influence the availability and quality of invertebrate populations to support foraging shorebirds and other waterbirds. Downstream of the dam, changes in ramping rates would alter flow conditions that support seed dispersal, germination, and establishment of emergent and woody vegetation, which could result in long-term changes to the viability of herbaceous, shrub-scrub, and forested wetlands along the shoreline. Faster ramping rates along with hourly or daily operational changes would generally be expected to produce more adverse effects than slower ramping rates, and less volatility in flow volume.

As a result of potential effects to wetland habitats, changes in water surface elevations and river conditions could cause beaver and muskrat to locate dens and lodges to new or different locations compared to where they currently occur under the No Action Alternative. Similarly, changes in water surface elevations during the breeding season would impact the western grebe colony nesting in the Pend Oreille WMA, particularly in Denton Slough. Increases to ramping rates in the breeding season could destabilize floating nests and cause them to break apart or become unstable. As a result, grebes would experience increased rates of egg loss and juvenile mortality, decreasing overall reproductive success. Furthermore, changes to the frequency of wetting and drying cycles in wetland habitats in Denton Slough would affect the availability and quality of the plant material used for nest construction. If pool conditions change rapidly, grebe and other waterfowl nests would be pulled from protected portions of the slough into the main reservoir where they would experience increased exposure to motorized boat traffic, predators, and extreme weather (Hull 2019). As a result, grebes and other waterfowl would experience higher rates of nest failure compared to the No Action Alternative.

In regard to potential effects in Canada, the effects to vegetation and wildlife resources and their habitats under MO3 are expected to be similar to the effects described for the United States portion of Region A

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

At Grand Coulee Dam, MO3 comprises five operational measures in the study area: *Ramping Rates for Safety*, *Update System FRM Calculation*, *Planned Draft Rate at Grand Coulee*, *Grand Coulee Maintenance Operations*, and *Lake Roosevelt Additional Water Supply*. These measures are intended to limit ramping rates for safety purposes only; reduce the risk of landslides around Lake Roosevelt in the winter and spring; provide operational constraints to maintain hydraulic capacity; increase reservoir capacity to protect against rain-induced flooding in Portland, Oregon, and Vancouver, Washington; and support water diversions for irrigation and withdrawals for municipal and industrial uses. Collectively, these measures minimally influence water surface elevations in Lake Roosevelt and downstream reaches of the Columbia River, as well as outflow from Grand Coulee Dam.

Implementing the operational actions under MO3 would have a range of effects in Grand Coulee Dam study area; however, there are only minimal changes to water levels on an average water year as a result of those operational changes, thus negligible effects to floodplains would be expected. Diverting water for irrigation results in minimal changes in water surface elevations immediately upstream of the dam in Lake Roosevelt (approximately 0.5-foot increase during the winter months, and less than 1.0-foot decrease during the spring months). These changes are more similar to No Action Alternative conditions than either the MO1 or MO4 alternatives. A decrease of 1.0 foot in water surface elevations during the growing season (April to October) would affect emergent herbaceous wetland habitat. However, the water surface elevation returns to conditions consistent with the No Action Alternative by May and this change is not anticipated to result in changes to habitat conditions in Lake Roosevelt under MO3, and as a result, no effects to local wildlife are expected to occur under MO3. Consequently, these measures have little to no effect on the quantity, quality, and distribution of habitats in the study area and, therefore, low potential for negative effects to wildlife populations in the study area.

In regard to potential effects in Canada, the effects to vegetation and wildlife resources and their habitats under MO3 are expected to be similar to the effects described for the United States portion of Region B

At Chief Joseph Dam, MO3 includes the *Chief Joseph Dam Project Additional Water Supply* measure, which diverts water from the Columbia River during the growing season (April through October) to support irrigation on authorized lands downstream from the dam. However, despite the loss of this water from the river system, there is less than a 1 percent change in water surface elevations to the river immediately downstream of Chief Joseph Dam, and changes are less measurable further downstream. As a result, the *Chief Joseph Dam Project Additional Water Supply* measure is not expected to result in measurable effects to floodplains, habitats, or wildlife populations upstream of Chief Joseph Dam. Changes downstream of Chief Joseph Dam are negligible and would not affect habitats or wildlife populations under MO3.

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

Structural measures associated with MO3 in Region C include *Breach Snake Embankments* and *Lower Snake Infrastructure Drawdown*. These measures breach the four dams on the lower Snake River. These structural measures are intended to increase downstream survival of juvenile salmon and steelhead, and improve upstream passage conditions for adult salmon, steelhead, and lamprey. In addition, these structural measures would result in widespread effects to floodplains, wildlife habitats, and populations. Partial breaching of the dam infrastructure would not affect the timing or volume of river flows (although water particle travel time would be faster) but would eliminate the reservoir environment. The *Lower Snake Infrastructure Drawdown* measure would provide additional equipment to minimize adverse effects of TDG during drawdown procedures.

Three operational measures are associated with MO3: *Drawdown Operating Procedures*, *Drawdown Contingency Plans*, and *Ramping Rates for Safety*. Because the dams would be removed from the system, operations for Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Dams would occur only during activities associated with breaching to facilitate the safe and efficient drawdown of the reservoirs, and then operations would cease at these projects. Operations at Dworshak Dam would continue to discharge flows on the Clearwater River, partially influencing flows in the lower Snake River. See Section 3.2 and 3.3, *Hydrology and Hydraulics*, for greater detail on changes to sediment transport and hydrology. Ramping rate limitations would be defined only for the purpose of safety or geotechnical concerns such as erosion. The purpose is to increase flexibility in flows to allow water to be shaped for hydropower production to meet power demand.

Increasing ramping rates at Dworshak Dam would cause vegetation to become dislodged and create unvegetated islands/shoreline environments. In addition, ramping rates can strand fish, macroinvertebrates, and other organisms within the barren zone. These events can cause desiccation of amphibian eggs or dislodgement of ground-nesting birds.

For the lower Snake River projects, construction activities associated with breaching the dams and specific effects to existing habitats and wildlife would be detailed in a future NEPA document, but the analysis below provides an overview of expected changes to Region C under MO3. Breaching the lower Snake River dams would decrease average surface water elevations, resulting in both short- and long-term effects to floodplains, habitats, and wildlife populations in Region C. Although changes to habitats and plant communities, and corresponding changes to wildlife populations, would shift over time, the duration of short-term effects from habitat loss and the time needed for habitats to transition from one type to another are uncertain.

The analysis below summarizes effects to habitat and wildlife in two time periods: short-term and long-term effects. These time periods are not mutually exclusive, nor do they represent the same span of time for every habitat type or species group. Rather, these time frames contextualize the effects and are a tool to evaluate trends over time. In general, short-term effects to plant communities would occur within 10 years of dam breaching; long-term effects or changes would occur after a minimum of 60 years. Wildlife populations respond to changes in habitat more quickly, and, as a result, short-term effects to wildlife would occur within 5 years of dam breaching and long-term effects to wildlife would occur after 5 years.

Short-term construction activities associated with breaching of earthen embankments at each dam and the subsequent construction of diversion dams (such as stockpiling and haul road construction) would have adverse effects on upland habitats and associated wildlife for the duration of construction. These effects include, but are not limited to, ground disturbance, soil compaction, removal of vegetation, surface hardening, noise, and human presence. Construction activities include construction of haul roads, equipment storage, and stockpile and staging areas. As described in Chapter 2, breaching the four dams would occur over a space of 4 years, 2 years to breach Lower Granite and Little Goose Dams, and 2 years to breach Lower Monumental and Ice Harbor Dams. Adverse effects from construction activities would be minimized by implementing BMPs.

Water surface elevations would drop approximately 95 to 110 feet in some places and approximately 13,800 acres of bare substrate (mostly sand and silt) would be exposed along the banks of the river following deconstruction. Approximately 3,000 acres of habitat management units that are currently irrigated under the No Action Alternative would no longer be irrigated, and these lands would transition to upland plant communities. Therefore, the quantity and distribution of shrub-steppe and grassland habitats would increase under MO3. Approximately 12,440 acres would be expected to transition from lands currently inundated under the No Action Alternative to upland habitats under MO3.

Until vegetation establishes along the shorelines, which may take 5 to 15 years, erosional processes and accretion would continue to modify and shape the riverbanks. Immediately after breaching the dams in the lower Snake River, approximately 350 acres of emergent herbaceous and forested and scrub-shrub wetland habitats in embayments, off-channel sloughs, and other still-water and fringe areas around the reservoirs would be lost as water levels drop, and these habitats would transition to upland plant communities. Plant species in these habitats that would be sensitive to the drawdown include shallow rooting plants such as willows (*Salix* spp.), false indigo bush (*Amorpha fruticosa*), and white alder (*Alnus rhombifolia*). Wetland vegetation along tributary streams, seeps, and springs would be retained after dam breach, as these habitats would be supported by groundwater from tributary systems. Additionally, well-established forested and scrub-shrub wetlands that are currently dominated by drought-tolerant plant species may be retained in areas nearer to the mouth of the Snake River.

Because most emergent herbaceous and forested and scrub-shrub wetlands are linked to hydrologic regimes associated with the Snake River, changing conditions from a reservoir system to lower elevation riverine system would cause major effects on the occurrence of floodplains, and would impact long-term habitat quantity, quality, and distribution throughout the 140-mile section of river. Approximately 1,900 acres of wetland habitats would be lost. These habitats would transition quickly to upland habitats. Over the next 15 to 60 years, approximately 1,500 acres of new wetland habitats would develop along the riverbanks.

As the river stabilizes after breaching, a variety of plant communities and habitats would develop along the shorelines. The structure and function of these habitats would be guided by biological, physical, and hydrologic conditions and various management decisions by state, Federal, and tribal entities. The types and species of plants that would colonize the exposed shorelines would be dictated by the distribution of seed stocks within the substrate, the presence of wind and water-borne seeds, and hydrologic conditions. Robberecht (1998) found that there is a sufficient seed bank in the shallow areas of the reservoirs (i.e., less than 15 feet water depth) to allow for rapid colonization of exposed banks. Below that depth, the viability and abundance of seeds diminishes, and active restoration is needed to support desired plant communities. For dam breaching of this extent, native vegetation would not establish without mitigation efforts that include planting and seeding as well as invasive species management.

Robberecht's findings also suggest that newly established plant communities within the upper 15 feet of the barren zone would be composed predominantly of native herbaceous species; however, a substantial amount of non-native seeds were also identified in the substrates. Due to the presence of non-native seeds and the potential for wind and water dispersal, it is possible that non-native plant communities would dominate the majority of the exposed lands following drawdown. Some of the more widespread non-native species identified by Robberecht (1998) include prickly lettuce (*Lactuca serrola*), puncture vine (*Tribulus terrestris*), curly dock (*Rumex crispus*), common yellow sweetclover (*Melilotus officialis*), water-cress (*Nasturtium officinale*), Russian thistle (*Salsola soda*), and bull thistle (*Cirsium vulgare*). Existing stands of non-native purple loosestrife, flowering rush, and reed canary grass would decline after dam breaching because these species are associated with wetland habitats; however, the newly exposed shorelines would provide habitat for these and other non-native species to establish as habitats stabilize over time. The success of native plant communities would be determined by several factors, including the degree of floodplain connectivity and the frequency and duration of inundation, and land management actions, including implementation of invasive species control.

Prior to construction of the dams, the lower Snake River contained a mosaic of approximately 3,285 acres of emergent herbaceous and forested and scrub-shrub wetlands (Corps 1975, 1991). Historical aerial imagery of the lower Snake River indicates approximately 1,500 acres of forested and scrub-shrub habitats could develop after dam breaching. These habitats would provide breeding and foraging habitat for a wide variety of wetland and upland species. Compared to No Action Alternative conditions, deep sediment deposits adjacent to the post-breaching river corridor would be more conducive to the establishment of wetland habitats than the rocky, shallow soils immediately adjacent to existing shorelines. Similarly, the wider, flatter shorelines of the post-breach river corridor would also support wetland habitat establishment and development compared to the steep side-slopes of current conditions. Over time, natural processes of erosion, accretion, and nutrient transport could support the development of high-quality wetlands distributed throughout the lower Snake River.

Under MO3, the existing reservoirs would be drawn down and habitat conditions would change in the study area as described above. The resulting draw down would result in a substantial change to the character of vegetation and water quality along the Snake River between its confluence with the Clearwater River and its mouth where it flows into the Columbia River. These changes would include the loss of approximately 1,200 acres of woody vegetation along the existing shorelines of the reservoirs, increased risk of invasive species establishment, and degraded water quality from high suspended sediments and turbidity from sediment movement, erosion, and bank sloughing (Table 3-105). These changes in habitat and water quality would result in short- and long-term effects to wildlife, both adverse and beneficial. Animals which are dependent on wetland habitats, such as amphibians, would be impacted by widespread losses of these habitats during and immediately after dam breaching; individuals would die if adjacent wetland habitats were inaccessible. Conversely, some wildlife would experience temporary benefits from breaching the dams, such as shorebirds that would benefit from an expansion of foraging habitat when mudflats are exposed during and after dam breaching.

**Table 3-105. Estimated Short-term Habitat Losses and Long-term Habitat Gains in the Study 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** |

1/ These are gross numbers. They do not factor in potential mitigation through maintenance of irrigation in habitat management units or continued development in Corps Managed Lands.
2/ Long-term gains are based on the assumption that habitats will return to their pre-project distribution. It does not assume that habitat management units or Corps Managed Lands will be maintained. Exact distribution of habitat types following drawdown is not quantifiable.
3/ Not included in the total.
Source: HEP Analyses 1995; Corps 2002

Wildlife can easily access water from the reservoirs under the No Action Alternative. Because the dam breach would create a wide barren zone between the river channel and vegetated upland habitats, access to water would be limited to wildlife who can safely traverse the barren zone, or access tributary streams, springs, and seeps. Individuals traversing the barren zone, such as gallinaceous birds like chukar and quail or small mammals, would experience increased risk of predation while foraging or accessing water at the river's edge. For several years after dam breaching, natural cover for roosting, feeding, escaping, or nesting along the approximately 13,800 acres of exposed shorelines, mudflats, and islands would be limited or non-existent.

Implementing MO3 could have varying effects on upland mammals such as elk, bighorn sheep, black bear, and mountain lion. These species occur in very low numbers in the lower Snake River Canyon and are not highly associated with wetland habitats Large mammals that are associated with forested wetland habitats, such as mule and white-tailed deer, would be temporarily adversely impacted by a reduction in suitable foraging habitat and protective cover during and immediately following dam breaching as existing wetland habitats transition to upland grassland or shrub-steppe habitats. As wetland and woody vegetation establishes along the river channel, more contiguous habitat conditions would increase the quantity of area over the long term by providing protective cover for migrating and transient upland mammals.

Winter conditions for mule and white-tailed deer would improve compared to No Action Alternative conditions as brush and woody vegetation becomes established in the river corridor. In 1984, the then Washington Department of Game and USFWS estimated that the amount of prime wintering habitat lost following inundation of the lower Snake River was capable of supporting 1,200 deer. Breaching the dams would result in a loss of approximately 1,200 acres of forested wetland habitat; however, it is anticipated that approximately 1,500 acres of emergent herbaceous and forested and scrub-shrub wetland habitats would develop along the new river channel. Furthermore, as vegetation becomes established on the exposed shorelines, these areas would provide additional foraging habitat for deer. Islands formed after drawdown would provide fawning habitat for deer if islands were inaccessible to mammalian predators. Currently, only New York Island at RM 78 provides suitable cover for fawning. Following implementation of MO3, newly exposed islands would provide refuge and suitable protective cover for deer during fawning.

Mammals such as coyote and bobcat would experience short-term benefits from increased availability of prey resources such as waterbirds, invertebrates, and small mammals that are exposed after dam breach from a lack of cover. The widespread loss of approximately 670 acres of wetland habitats would reduce the availability of emergent herbaceous and forested and scrub-shrub wetlands for shelter and breeding habitat until these habitats become established along the banks of the new river channel. Aquatic mammals, such as otter, beaver, raccoon, and muskrat would experience loss of breeding, foraging, and sheltering habitat and degraded water quality during and immediately after dam breaching. High turbidity would adversely impact foraging success until suspended sediments settle out of the water column and increase visibility (see Section 3.4, *Water Quality*).

Under the No Action Alternative, reservoir conditions support abundant otter populations because substantial denning habitat is available on the reservoir shorelines. Dam breaching and reservoir drawdown would decrease the number of denning sites and isolate existing dens from the river. As a result, the overall population of otters may temporarily decline following implementation of MO3 because denning habitat would be limited and the availability of fish resources in the years following dam breaching would support fewer individual otters. Muskrat and beaver are closely associated with emergent riparian habitats, which would be lost during and immediately following dam breaching. Breeding and foraging habitat for these species would be limited until vegetation and wetland habitats are reestablished several years after dam breaching and individuals may experience increased predation. However, individuals would return to the system when food resources and shelter develops in forested and shrub-scrub wetlands. Over time, populations of terrestrial and aquatic mammals would recover and stabilize as habitats transition and become established along the river corridor.

Small mammals would experience increased predation and habitat loss under MO3. Rocklage and Ratti (1998) found more individuals and overall diversity of small mammal species in wetland sites than upland or grassland habitats in the lower Snake River study area. Loss of wetland sites would increase exposure of small mammals to predators as habitats transition to upland habitat types. However, the risk of predation would diminish over time as populations become established in wetland habitats after they develop along the new river channel. If wetland habitats are more contiguous along the new river channel compared to the No Action Alternative, long-term population numbers for small mammals may increase where suitable habitat exists and covers more area. It is estimated that approximately 1,500 acres would develop into emergent herbaceous and forested and scrub-shrub wetlands adjacent to the river channel compared to approximately 1,200 acres that exist under No Action Alternative. Small mammal species associated with upland grassland or shrub-steppe habitats, such as Ord's kangaroo rat (*Dipodomys ordii*) or bushy-tailed woodrat (*Neotoma cinerea*), would benefit from the transition of habitats because the availability and distribution of upland habitat would increase by approximately 12,500 acres following dam breaching and reservoir drawdown.

Bats in the study area would be adversely impacted by a reduction in invertebrate and insect prey resources following dam breaching. Reducing the surface area of reservoirs would result in a loss of breeding habitat for invertebrate species. Many embayments and off-channel habitats would be exposed and isolated from the river channel following dam breaching and drawdown. These areas support insect reproduction and overall productivity of the food web. Species most likely to be affected by a reduction in insects following a reduction of wetland and ponded habitats include Townsend's big-eared bat and the Yuma myotis. Furthermore, as existing wetland habitats transition to upland habitats, roosting habitats for bats would decline until woody vegetation becomes established adjacent to the river corridor in future years. Approximately 650 acres of rocky habitat would be exposed from reservoir drawdown. These habitats provide roosting or hibernacula habitat for Western pipstrelle bats (*Pipistrellus hesperus*).

During and immediately following implementation of MO3, waterfowl populations in the vicinity of the four dams would experience loss of shallow-water habitat and increased risk of predation. Several years after dam breaching, emergent herbaceous and forested and scrub-shrub habitats would establish along the new river channel and these habitats would increase compared to current conditions under the No Action Alternative. The then Washington Department of Game and USFWS (1984) estimated that approximately 120,000 pheasants, quails, and doves were displaced when the dams were constructed and forested wetland habitats were inundated. A series of isolated, irrigated habitat management units currently provide habitat for these species under the No Action Alternative. As forested wetlands become established along the new riverbanks, these areas would support breeding and foraging habitat for birds and populations would likely increase compared to No Action Alternative estimates. Once wetland and off-channel habitat become established along the banks of the river following implementation of MO3, this habitat would provide productive breeding, foraging, sheltering, and wintering habitat for waterfowl in the lower Snake River study area.

The availability of island habitats would increase compared to conditions under the No Action Alternative. Approximately 50 islands, each greater than 5 acres, supported nesting habitat for Canada geese and were inundated behind the lower Snake River dams (Corps 1988; Washington Department of Game and USFWS 1984). These islands provide suitable habitat for nesting Canada geese and other waterfowl after vegetation and protective cover becomes established. If these islands develop suitable habitat to support waterfowl nesting and the islands are land-bridged, nesting waterfowl would experience increased risk of predation from mammalian predators. In 1976, Asherin and Claar found that decreased water surface elevations in the McNary reservoir exposed land bridges to Badger and Foundation Islands, as well as three of the five Hat Islands and coyote predated geese nesting on these islands. Conversely, if the islands were effectively isolated from the mainland, habitat would be more suitable for nesting waterfowl. In addition, the large sediment loads currently stored behind the four dams would provide source material for new sandbars and shallow-water areas as the river establishes a new thalweg.

Wintering waterfowl would experience disturbance during dam breaching and individuals would relocate to other areas outside of the construction areas. Degraded water quality and sediment transport processes would limit aquatic prey resources and foraging success for waterfowl dependent on aquatic invertebrates and fish both during and immediately following dam breaching and reservoir drawdown. Habitat conditions would change from slow-moving reservoirs with submerged aquatic plants such as pondweeds and waterweeds, to a higher velocity riverine system that would minimize the potential establishment of submerged aquatic plants. Decreasing the quantity and distribution of submerged aquatic vegetation would decrease foraging resources for waterfowl and diving ducks like American coot and American widgeon (*Mareca americana*). As a result, waterfowl production on the lower Snake River would decline for several years after dam breaching. While vegetation growth on newly exposed mudflats would increase the availability of foraging habitat for individuals foraging on grasses, the combination of increased exposure to predators, heavy weedy growth, and unstable shorelines would create barriers to the river for young birds, and potentially result in adverse effects to birds for several years. The breaching of the dams would cause the decrease of lake habitat waterfowl, including scaups, mallard ducks, bufflehead, Barrows goldeneye, merganser, and benefit species that prefer river, riparian, and upland habitats such as yellow warbler.

Once shallow-water habitats and wetlands begin to establish several years after the drawdown, the quantity, quality, and distribution of foraging habitat would increase compared to No Action Alternative conditions. However, in the intervening years between drawdown and habitat establishment, breeding, foraging, and winter waterfowl would likely relocate to other areas in the Pacific Flyway where resources are abundant. Some small wetlands would develop on newly formed islands resulting from sediment deposition.

Implementing MO3 would increase the quantity of exposed mudflats available for foraging for migrating and resident shorebirds such as killdeer (*Charadrius vociferous*) and spotted sandpiper (*Actitis macularius*) compared to the No Action Alternative (Taylor and Trost 1992). However, this benefit would decrease as these mudflats become vegetated by wetland or upland plant communities. These habitats are unsuitable or less suitable for shorebird nesting. The seed bank along the lower Snake River has the potential to support rapid recolonization in the upper 15 feet of the existing reservoir (Robberecht 1998). During and immediately following dam breaching and reservoir drawdown, migratory shorebird abundance would fluctuate with changes in habitat availability and abundance of exposed mudflats. Abundance and species richness would return to current estimates as habitats stabilize over time.

While colonial nesting waterbirds are present in the Columbia River Basin and individuals forage along the lower Snake River, nest colonies are uncommon in Region C. Under MO3, dam breaching and reservoir drawdown would increase the quantity of exposed areas and islands available as nesting habitat for species such as Caspian tern (*Hydroprogne caspia*), double-crested cormorant (*Phalacrocorax auritus*), American white pelican (*Pelecanus erythrorhynchos*), and numerous gulls. Prey resources in the lower Snake River for fish-eating water birds would decrease during and immediately following dam breaching. However, model results for fish populations suggest an increased abundance of returning adult salmon and steelhead populations several years after dam breaching. As a result, the abundance of juvenile fish produced by these returning adults is expected to increase. However it should be noted that upon the breaching of the lower Snake River dams, Bonneville would no longer have an obligation to fund U.S. Fish and Wildlife Service for the operations and maintenance of the Lower Snake River Compensation Plan hatchery facilities, because Bonneville's funding authority is directly tied to the operation of the lower Snake River dams. This could result in fewer hatchery juvenile fish being released into the lower Snake River from these facilities, however the co-lead agencies recognize that transitional needs will be addressed as the effectiveness of dam breaching is assessed (see further discussion in Section 3.5.3.6).

In addition, the large quantity of sediment stored behind the four dams would provide source material for sandbars and shoreline habitat to support nesting waterbirds like gulls and terns. As shorelines become vegetated, habitat suitability for nesting would decrease. In contrast to gulls and terns, the development and growth of woody vegetation would support nesting habitat for herons and other waterbirds that are not present above Ice Harbor Dam (Rocklage and Ratti 1998; Corps 1999). Based on observations of nesting waterbirds before the dams were constructed, double-crested cormorants may use habitats as they develop features develop which support roosting or nesting (Weber and Larrison 1977). This would be different from current conditions where cormorants are not observed nesting in the lower Snake River.

Raptors like northern harrier (*Circus cyaneus hudsonius*), red-tailed hawk (*Buteo jamaicensis*), and owls which are associated with wetlands, would experience a reduction in breeding, nesting, and perching habitat. They would also be affected by changes in the availability of prey resources as forested wetlands transition to drier, upland habitats following drawdown. As small mammal populations and water birds respond to habitat loss and populations shift to areas outside of the drawdown area in the years after dam breach and drawdown, raptors would have to shift to other prey resources. As wetland habitats become established along the new river channel, raptor populations would respond to increases in prey resources over time. In addition, as rocky habitats and cliffs are exposed following drawdown, nesting habitat for falcons and other cliff-nesting raptors would increase compared to current conditions under the No Action Alternative. Owls and other cavity-nesting raptors would benefit from the development of snags where the existing reservoir shorelines provide mature trees. Approximately 12,500 acres of upland habitat would increase the availability of open hunting space for species such as American kestrel (*Falco sparverius*) and northern harrier. As forested wetland habitats become established over time, mature trees would provide nesting sites for fish-eating raptors like osprey. Overall, there would be long-term increases in fish-eating raptors, especially, because there would be better and more perch sites available, as well as more exposed mud flats. In the short term, there may be some losses of perch sites, however.

In Region C, wetland habitats adjacent to the reservoirs support the highest species diversity and overall abundance of birds compared to other habitat types (Asherin and Claar 1976; Rocklage and Ratti 1998). The loss of approximately 160 acres of emergent herbaceous wetlands and an additional 1,200 acres of forested and scrub-shrub wetland habitats from reservoir drawdown would adversely impact a wide variety of birds by reducing the quantity, quality, and distribution of breeding and foraging habitat for migratory songbirds like orioles, sparrows, flycatchers, and warblers, raptors like Cooper's hawk (*Accipiter cooperii*) and northern harrier, and owls like western screech and great horned (Rocklage and Ratti 1998). As wetland habitats become established along the new river channel, the quantity, quality, and distribution of habitats supporting breeding and foraging habitat would increase and may exceed current habitat conditions. It would take 20 to 50 years before forested wetlands have mature deciduous trees and a diversity of structure to support a diverse assemblage of migratory songbirds, raptors, and owls. Emergent herbaceous wetlands would develop along shorelines and off-channel areas of the new river channel, supporting marsh birds like wrens, blackbirds, and wading water birds.

MO3 would adversely affect reptiles and amphibians during and immediately following dam breaching and reservoir drawdown. Reptiles are generally more mobile than amphibians and less dependent on aquatic habitat, with the exception of turtles. The Chief Timothy habitat management unit supports an isolated population of western painted turtles (*Chrysemys picta belli*) which would be lost as habitat management unit habitats transition to drier, upland habitats following drawdown. The permanent reduction in water surface elevations and loss of riparian and wetland habitats would isolate amphibian populations, desiccating eggs or juveniles that are not able to relocate to adjacent wetland habitats. Loper and Lohman (1998) experimentally showed that amphibian eggs exposed to desiccation for approximately one day are no longer viable. Amphibian populations would therefore experience population-level declines following a widespread, generational loss of eggs and juveniles along some stretches of the river. Over time, however, the species assemblages would reestablish along the new river channel as shallow water habitats, emergent herbaceous, and forested and scrub-shrub wetlands become established. Over time, contiguous wetland habitats would improve habitat connectivity to support dispersal and movement for reptiles and amphibians, supporting overall improvements to habitat quantity, quality, and distribution compared to the No Action Alternative.

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

Nine structural measures are associated with MO3 in Region D: Additional Power Surface Passage, *Fewer Fish Screens*, *Upgrade to Adjustable Spillway Weirs*, *Modify Bonneville Ladder Serpentine Weir*, *Lamprey Passage Structures*, *Turbine Strainer Lamprey Exclusion*, *Bypass Screen Modifications for Lamprey*, *Lamprey Passage Ladder Modifications*, and *Improved Fish Passage Turbines*. These structural measures are not expected to result in widespread effects to floodplains, wildlife habitats, or populations.

Under MO3, there would be no changes to the reservoir elevations at McNary, The Dalles, or Bonneville Dam. At John Day Dam, the *John Day Full Pool* measure calls for operating the reservoir between 1.5 to 2.5 feet higher than the No Action Alternative from March 15 to September 30. Operational measures associated with MO3 in Region D are *Spring Spill to 120% TDG*, *Reduced Summer Spill*, *Ramping Rates for Safety*, *John Day Full Pool*, *Above 1% Turbine Operations*, and *Contingency Reserves in Fish Spill*. See Sections 3.2, *Hydrology and Hydraulics*, for greater detail on changes to sediment transport process and hydrology under MO3, and corresponding changes to these resources following dam breaching. Implementing the structural and operational dam breaching measures in Region C in concert with the *John Day Full Pool* measure would impact wildlife habitats and populations in Lake Umatilla. Between Bonneville and John Day Dams, changes in pool elevations are negligible, and river conditions in Lake Bonneville and Lake Celilo do not change measurably from the No Action Alternative, resulting in no expected changes to wildlife habitats in these areas. Downstream of Bonneville Dam, water levels change slightly immediately downstream of the dam, and details are provided below.

Under MO3, the majority of sediment released from the reservoirs on the lower Snake River following embankment breaching would be deposited in Lake Wallula between the confluence of the Columbia with the Snake River and Wallula, Washington. In the near term, within the Snake River corridor sediments would deposit along newly exposed shorelines and would support the development of emergent herbaceous and forested and scrub-shrub wetlands. As sediments are transported by the Snake River, they are expected to accumulate within the lower subreach near the confluence of the Columbia and the Snake River (see Appendix C, *River*

*Mechanics*). Most of the sediment would settle along the channel margins, however, sediment deposition would also occur along the banks of the Columbia River and deposits could be 5 to 15 feet in depth. However, because the McNary Reservoir is greater than 20 feet deep, most sediment deposition in the Columbia River channel would lie below the average water surface elevation and would not develop into vast wetland complexes. Over the long term, watershed sediment loads would also be routed to the confluence area.

Any exposed sediment would increase mudflats and potentially establish as invasive plant species to spread and become established as they spread into areas where they do not occur under the No Action Alternative. The overall distribution and quantity of invasive species in upper portions of Region D above McNary Dam would likely increase under MO3, which would result in a reduction of habitat quality for a suite of wildlife until native species become established. To offset this effect the co-lead agencies are proposing to plant approximately 155 acres of emergent and forested scrub-shrub wetland habitats on the Columbia River downstream of the confluence with the Snake River and to excavate newly deposited soils on the 155 acres to maintain the hydrologic conditions necessary to support wetland habitats is proposed to offset this effect. As a result, the overall distribution and quantity of invasive species in the lower portion of  Region D below Bonneville Dam is not expected to increase under MO3 compared to the No Action Alternative and therefore no changes to wildlife populations are expected due to effects of operations of the CRS on invasive species. Where no management efforts are implemented, invasive species are expected to persist under MO3 similar to the No Action Alternative.

Similar to the effects described in MO1, forested and scrub-shrub and emergent wetlands in Lake Umatilla would be impacted by the increased water surface elevations in April and May under MO3, including the extensive wetland complex at the Umatilla National Wildlife Refuge. Prolonged inundation during the early part of the growing season would result in a 40 percent expansion of shallow water habitat, an expansion of wetland plant communities, or shift the composition of plants to species more tolerant of prolonged inundation. If the overall quantity, quality, and distribution of emergent herbaceous and forested and scrub-shrub wetlands expand under MO3 compared to the No Action Alternative, wetland habitats are expected to increase overall productivity in Lake Umatilla, supporting breeding amphibians, reptiles, mammals, and birds during the spring and summer breeding season. Improved wetland habitats would also support regionally important migratory waterfowl overwintering in the Umatilla NWR Important Bird Area by increasing forage opportunities and prey resources.

Over time, shallow-water habitats and wetlands would begin to establish several years after the drawdown, the quantity, quality, and distribution of foraging habitat would increase compared to No Action Alternative conditions. However, in the intervening years between drawdown and habitat establishment, breeding, foraging, and winter waterfowl would likely relocate to other areas in the Pacific Flyway where resources are abundant. Individuals would move from the lower Snake River to Lake Umatilla and Lake Wallula on the Columbia River near John Day and McNary Dams, however, shallow-water habitats in these areas would similarly experience sediment deposition, which would decrease food resources. Over 50 percent of sediments trapped behind the four dams would be deposited north of Wallula Gap along the left river bank in and adjacent to the McNary National Wildlife Refuge (see Appendix C for details about River Mechanics) over approximately 14,600 acres of the reservoir, including approximately 155 acres of adjacent forested and scrub-shrub and emergent wetlands. It is unknown how or if this deposition would affect waterfowl displaced from the Snake River reservoirs; however, where the quantity and quality of wetlands decrease after dam breaching, waterfowl and other wildlife populations would be displaced from the immediate area until habitat reestablishes in the years following the second phase of dam breaching.

Downstream of John Day, changes in minimum water surface elevations under MO3 are consistent with the natural range of variability and fluctuations from daily operations. Consequently, the quantity, quality, and distribution of habitats would not deviate measurably from the No Action Alternative. As a result, implementing MO3 would not result in a conversion of habitats that would measurably affect wildlife populations.

Minor reductions in flood elevations would occur below Bonneville Dam for floods that occur with moderate frequency, which could have minor effects on floodplain benefits in this region. On average, changes in river levels downstream of Bonneville Dam would be less than 3 inches and within the natural range of variability in daily water levels. For this reason, MO3 is not expected to cause measurable effects to wildlife populations or their habitats downstream of Bonneville Dam. The lower portions of the Columbia River would continue to support valuable habitat for fish and wildlife, and current trends are expected to continue.

In locations where ODFW or WDFW manage wetland habitats for wildlife, operations and maintenance actions under MO3 are assumed to continue similar to current practices under the No Action Alternative, including actions at Klickitat Wildlife Area and Sondino Ponds in Washington State for western pond turtles. It is assumed that wildlife concentrations and use of habitats in the lower Columbia River and Columbia River estuary would not change under MO3 from current conditions as described in the No Action Alternative.

The fish modeling for MO3 indicates juvenile salmon and steelhead have a higher survival compared to the No Action Alternative and fish would move through the system faster compared to No Action Alternative conditions. Water quality throughout the lower Columbia River would be poor for several years after dam breaching and turbidity would be high during the spring freshet. These conditions decrease foraging opportunity and success for fish-eating birds, which would influence reproductive success for the colonies. As a result, existing nesting colonies would shrink or move to other locations in the region until habitats become established and turbidity inputs decrease over time.

Hydrology and hydraulics model results do not show measurable changes in water surface elevations in Lake Umatilla, with the exception of an increase in pool elevations in April and May by as much as 2.5 feet compared to the No Action Alternative from implementing the *John Day Full Pool* measure. The effects of this measure would be consistent with the effects described in greater detail for the *Predator Disruption Operations* measure under MO1. In general, nesting habitat including on Blalock Island, for colonial nesting water birds like terns and gulls, would be inundated during the early part of the breeding season when birds typically initiate nesting activities. These effects are consistent with effects described in the MO1 *Predator Disruption Operations* measure. Consequently, birds would delay breeding until later in the summer when pool elevations decrease and expose suitable nesting habitat or relocate to other areas within and outside the Columbia River Basin.

**FLOODPLAINS**

Under MO3, changes in flood elevations would typically be negligible (absolute value less than 0.3 feet) across the Columbia River Basin for all flood frequencies, from regularly occurring floods (AEP of 50 percent) to the base flood (AEP of 1 percent). However, major changes in the floodplain would occur in Region C for the lower Snake River (below Dworshak Dam) under the *Lower Snake Infrastructure Drawdown* measure. The changes in river width, depth, and velocity resulting from this measure, as described in Appendix B, Part 1, *H&H Data Analysis*, would have large, short-term effects on the floodplain. In the long term, this alternative would be expected to ultimately restore the floodplain to a more natural condition. Over time, these changes would have a major, beneficial effect on floodplain values in the Snake River below Dworshak Dam.

**SPECIAL STATUS SPECIES**

This section discusses the potential effects of implementing MO3 on ESA-listed plant and animal species that may occur in the study area.

Implementing MO3 would indirectly benefit wintering bald eagles by increasing the availability of stranded salmon and other fish prey as water levels recede during the period of deconstruction. In the near term, trees used for roosting and nesting would decline as habitats transition following changes to water surface elevations. Over time, however, large trees could develop along the river channel and these trees would improve habitat conditions along the lower Snake River for eagles.

As described in Section 3.5, the fish models predict a moderate to major increase in smolt-to-adult returns and overall abundances of adult salmon and steelhead over the long term. There may be short-term adverse effect as a result of dam breach efforts that may cause disruption in foraging behavior of marine mammals and colonial nesting birds. Over the long term, this would lead to an increase the prey base available to marine mammals foraging in the Columbia River, such as seal or sea lion, or offshore from the mouth of the Columbia River, such as killer whale. This overall effect is moderate to major for sea lions and minor for Southern Resident 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 | *Ursus arctos horribilis* | ESA status: T<br>CH: proposed | Libby Dam<br>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.<br>**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.<br>**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 | *Odocoileus virginianus leucurus* | ESA status: T<br>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.<br>**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.<br>**Conclusion:** Negligible effect: MO3 effect to Columbia white-tailed deer is similar to NAA. MO3 is not likely to adversely affect the Columbian white-tailed deer. |
| California sea lion | *Zalophus californianus* | ESA status: None<br>CH: None<br>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.<br>**Hydrology:** Negligible Effect. Water surface elevation changes minimal (less than 1-foot difference) and within range of natural variation.<br>**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.<br>**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 | *Eumetopias jubatus* | ESA status: None<br>CH: None<br>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.<br>**Hydrology:** Negligible effect. Water-surface elevation changes minimal (less than 1-foot difference) and within range of natural variation.<br>**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.<br>**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 | *Orcinus orca* | ESA status: E<br>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.<br>**Hydrology:** Negligible effect. Water surface elevation changes minimal (less than 0.5-foot difference) and within range of natural variation.<br>**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.<br>**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 | *Coccyzus americanus* | ESA status: T<br>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.<br>**Hydrology:** Moderate effect to suitable habitat. Water fluctuations at Libby Dam would result in high winter flows that prevent establishment of cottonwoods galleries.<br>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.<br>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.<br>**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 | *Haliaeetus leucocephalus*<br>*Aquila chrysaetos* | Bald and Golden Eagle Protection Act | Throughout the study area. | **Construction of structures on the dam:** Negligible effect.<br>**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.<br>**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 | *Eremophila alpestris strigata* | ESA status: T<br>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.<br>**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.<br>**Conclusion:** No effect from operations under MO3. MO3 would not likely adversely affect streaked horned lark. |
| **Plants** | | | | |
| Ute Ladies'-tresses | *Spiranthes diluvialis* | ESA status: T<br>CH: None | Grand Coulee Dam<br>Chief Joseph Dam | **Construction of structures on the dams:** No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected.<br>**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.<br>**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.

**SUMMARY OF EFFECTS**

Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue, including protection, mitigation, and enhancement of wildlife habitat as discussed in Section 5.2.1. The effect of MO3 could be summarized by region, as follows.

In Region A, under MO3, water surface elevations on Lake Koocanusa would be decreased in winter and spring, and increased in late summer which would result in changes in the barren zone, emergent herbaceous, and forested and scrub-shrub wetland habitats adjacent to the reservoir. Because pool elevations would be lower for the majority of the growing season, wetland habitats would transition into upland habitats or plant communities. MO3 operations would support exposure of island habitats and development of nesting habitat in the spring and summer in Lake Koocanusa. Downstream of Libby Dam, high winter flows in the Kootenai River would inundate riverbanks and redistribute seeds from forested wetland vegetation. Higher water levels in the winter would increase bank sloughing and erosion, potentially degrading water quality for aquatic wildlife. Lower spring flows would reduce moisture content of soils, which would reduce the suitability of shoreline habitat in the spring and summer for seed deposition and plant establishment.

Also in Region A, the marginal changes in water flows and elevations downstream of Hungry Horse Reservoir, along the South Fork Flathead River from implementing MO3 would not alter floodplains, wetland habitats, vegetation communities, or wildlife populations compared to the No Action Alternative. Changes in water surface elevations and ramping rates during the western grebe colony breeding season in Denton Slough downstream of the Albeni Falls Dam could destabilize floating nests and cause them to break apart or become unstable. As a result, grebes would experience increased rates of egg loss and juvenile mortality, decreasing overall reproductive success. Overall, for Region A, there would be a moderate effect on wetlands, vegetation, habitat, and wildlife and a negligible effect to floodplains under MO3.

In Region B, the measures under MO3 would have negligible effects on floodplains, quantity, quality, and distribution of habitats and, therefore, low potential for negative effects to wildlife populations and a negligible effect to floodplains.

In Region C, MO3 dam breaching would result in the greatest wildlife, vegetation, wetland, and floodplain habitat effects. Dam breaching would result in a substantial change to the character of vegetation and wetlands along the Snake River between its confluence with the Clearwater River and its mouth where it flows into the Columbia River. Previously inundated areas would have vegetation permanently established, though the unvegetated soils in the previously inundated reservoir areas would be at increased risk of invasive species establishment. About 1,200 acres of woody vegetation would be lost along the existing shorelines of the reservoirs, but hundreds of acres of new habitat types, such as rocky outcroppings, would be added. Some wildlife species would benefit from the conversion of habitat while the changes in vegetation and habitat would have a negative effect on other species. Overall, the short-term effect of MO3 on Region C would be negligibly beneficial and would have major negative effects on vegetation, wildlife, wetlands, and habitats. In the long term, this alternative could ultimately restore the floodplain to a more natural condition, which would have a major, beneficial effect on floodplain values in the Snake River below Dworshak Dam. Long-term effects to wildlife and vegetation could be a major effect, as wildlife and vegetation would need to respond to sediment and major changes to hydrology. With mitigation efforts and implementation of an invasive species management plan, the overall long-term effect could be beneficial.

In Region D, sediments released during and after dam breaching would deposit along newly exposed shorelines and would support the development of emergent herbaceous and forested and scrub-shrub wetlands. Any wetlands impacted by sediment deposition following dam breaching would be mitigated to offset impacts to the overall quantity, quality, and distribution of emergent herbaceous and forested and scrub-shrub wetlands upstream of McNary Dam. As a result, there may be short-term impacts to breeding amphibians, reptiles, mammals, and birds during the spring and summer breeding season until wetlands become re-established in the years following dam breaching. For those areas downstream of McNary Dam, minimum pool elevations would not change from normal operations under the No Action Alternative. Consequently, MO3 is not expected to influence the quantity, quality, or distribution of habitats downstream of McNary Dam, and therefore, these changes are not expected to result in substantive or widespread changes to wildlife populations. Annual average probability of inundation would be unchanged from current conditions, with negligible effects on floodplains. Overall, the effect of MO3 on Region D would be negligible.

For special status species in all regions, multiple special status species would be impacted by MO3 beyond No Action Alternative conditions. Overall, there would be negligible effect on special status species.

#### *3.6.3.6 Multiple Objective Alternative 4*

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

No structural measures would be implemented in Region A under MO4 and, therefore, the proposed structural measures would not impact floodplains, wildlife habitats, or populations. Under MO4, operational measures are *McNary Flow Target*, *Sliding Scale at Libby and Hungry Horse*, *Modified Draft at Libby*, *December Libby Target Elevation*, *Hungry Horse Additional Water Supply*, and *Winter Stage for Riparian*. Collectively, these measures would influence operations in portions of Region A by altering draft and refill procedures at Libby and Hungry Horse, modify winter draft targets, and summer drafting (similar to measures proposed under MO1). Additionally, MO4 proposes to implement additional operations at Libby, Hungry Horse, and Albeni Falls to augment flows at McNary Dam and support growth and establishment of forested and scrub-shrub wetland habitats near Bonners Ferry, Idaho, by limiting outflow from Libby in the winter. Annual average probability of inundation is expected to remain unchanged from current conditions in Region A, with negligible effects on floodplains.

As discussed in Section 3.2, *Hydrology and Hydraulics*, pool elevations in Lake Koocanusa are generally higher under MO4 during mid-winter and mid-summer and generally lower during spring drawdown and late summer through early winter after refill compared to the No Action Alternative. The primary habitat type affected by implementing the *December Libby Target Elevation* measure is the barren zone, and the measure delays the draft to start in January compared to December under the No Action Alternative. Effectively, this delay in drawdown results in higher pool elevations through mid-February, but the greatest increase occurs in December when the pool is approximately 9 feet higher. Because this change in timing does not occur during the growing season or exceed the range of pool fluctuations the reservoir currently experiences, the *December Libby Target Elevation* measure does not result in widespread changes to the quantity, quality, or distribution of habitats or floodplains in the study area. The effects are similar to MO1.

When the *December Libby Target Elevation* is combined with the *Modified Draft at Libby* measure, the reservoir is drafted approximately 2 feet deeper in April, and summer refill increases pool elevations by approximately 1 to 1.5 feet. This increase during June and July would initiate vegetation establishment in the barren zone, which would support the establishment of emergent herbaceous wetlands in Lake Koocanusa and increase the overall quantity of wetland habitats compared to operations under the No Action Alternative. Increased summer water levels would also increase the functional quality of existing wetlands where they occur near tributary confluences, such as the Tobacco River. However, lower pool elevations in the late summer (i.e., July through October) would negate this trend and even result in an overall decrease in wetland habitats if they transition to uplands or if plant composition shifts to species more tolerant of dry conditions or drought. During average water years, pool elevations are 3 to 6 feet lower in the late summer, substantially lower (5 to 12 feet) in low water years. Libby elevations vary greatly according to the annual forecast; in high water events, the pool elevation is up to 5 feet higher during August and September. Changing the pool elevations would result in a loss of emergent vegetation to open water. Furthermore, abrupt decreases in water levels in Lake Koocanusa during middle and late summer are unlikely to affect nesting songbirds and waterfowl because young songbirds are mostly fledged by this time and young waterfowl have left the nest and are spending most of their time on the water. However, these decreases in water levels may expose young waterfowl to increased predation if they are forced to leave emergent vegetation and move into open water.

The changes proposed for Libby under MO4 occur both during and outside of the growing season. Changes in water levels during the growing season would alternately inundate and dry narrow bands of emergent vegetation, which influence aquatic and terrestrial wildlife. For example, the Kootenai Falls WMA has approximately 3 miles of river frontage, and the Kootenai NWR supports emergent herbaceous and forested and scrub-shrub wetlands adjacent to the river. While the Kootenai Falls WMA is managed for mule and white-tailed deer and bighorn sheep that would unlikely be impacted by changes in river levels, changes in river levels would convert wetland habitats adjacent to the river to forests or other upland habitat types (MFWP 2016). A conversion of wetlands to drier, upland habitat types would influence wetland-dependent species that would relocate to areas with suitable wetland habitat.

Wildlife partially or entirely dependent on wetland habitats for part their lifecycle could be impacted by the conversion of wetland habitats to drier forests or upland habitat types. Where possible, wildlife would relocate to other areas or shift to higher elevations to avoid inundation when river levels are higher than No Action Alternative conditions. Conversely, species that are entirely dependent on wetlands would be seasonally impacted by fluctuations in river levels. As temperatures begin to warm in the spring, changing river levels would influence habitat suitability for breeding birds and amphibians, impacting long-term phenology and fecundity. Off-channel habitat may dry intermittently during the growing season, which would desiccate amphibian tadpoles, such as those of the western toad. Aquatic invertebrates such as caddisflies and stoneflies larvae would experience similar interruptions in their lifecycle and over time, these interruptions could lead to changes in food web ecology and overall ecosystem function.

Implementing operational measures included in MO4 would cause notable changes in outflow from Libby and corresponding changes in river conditions on downstream portions of the Kootenai River. These changes are evidenced throughout the study area, and changes are less influential downstream as tributaries contribute inflows. Changes on the Kootenai River occur in winter as a result of the *Winter Stage for Riparian* and *McNary Flow Target* measures. High flows in June and July, followed by gradually receding water levels in subsequent months, allow for seedling establishment along the banks of the river. Implementing MO4 would lower water levels in the winter and reduce the likelihood of high water carrying seedlings downstream between November and March. The *Winter Stage for Riparian* measure would reduce the amount of time that flows inundate riverbanks by approximately 15 to 25 percent, thereby allowing tree and shrub seed germination and seedlings to become firmly established early in the growing season before the high flows flush through the system in June and July. As woody vegetation becomes established along the Kootenai River, the quantity, quality, and distribution of forested and scrub-shrub wetland could increase and support a wide variety of aquatic and terrestrial wildlife. This measure could reverse the trend of widespread losses in the quantity and distribution of cottonwood galleries along the Kootenai River within the active floodplain (KTOI 2013).

Reduced winter flows stemming from the *McNary Flow Target* and *Winter Stage for Riparian* measures would decrease bank sloughing and erosion at Bonners Ferry. Increasing the establishment and recovery of cottonwood galleries would increase canopy cover over the river, thereby increasing shade, lowering water temperatures, and increase species diversity and density of native wildlife. Increased shade over the river reduces water temperatures and supports fish and aquatic wildlife sensitive to high temperatures. Specifically, implementing the *Winter Stage for Riparian* measure is anticipated to improve aquatic habitat for species like white sturgeon and bull trout, as well as terrestrial habitat for species like western yellow-billed cuckoos.

Furthermore, increased canopy cover over the water increases the input of detritus and organic materials supporting invertebrates and the food web. Increasing the quantity, quality, and distribution of forested and scrub-shrub wetland habitats downstream of Libby would increase migratory corridors or link habitats which are currently fragmented and may attract migrant cuckoos into developing habitats. Increasing the availability of forested wetland habitat in the Libby study area would have ecosystem-wide benefits, including improved wetland and floodplain function. Higher quality habitat would provide more resources per acre, supporting higher densities of native wildlife.

After several years of implementing MO4 measures at Libby, habitat in the study area would stabilize, and the conversion of wetlands would create new boundaries between different habitat types. MO4 would not impact wildlife downstream of Libby and, while these changes would not be realized for several years or decades following implementation, long-term effects of the *Winter Stage for Riparian* measure would benefit wildlife. Operational changes at Libby under MO4 are also evident in downstream reaches of the Columbia River, as discussed in the sections on Regions C and D below.

In regard to potential effects in Canada, the effects to vegetation and wildlife resources and their habitats under MO4 are expected to be similar to the effects described for the United States portion of Region A.

Of all alternatives, MO4 results in the greatest differences at Hungry Horse for water surface elevations and outflows and the subsequent effects on vegetation and habitat. Water surface elevations in the reservoir would be lower throughout the year, with changes ranging from a decrease of approximately 1.0 to 6.0 feet in the summer to 6.0 to 12.0 feet in winter. Full pool would be reached about a week later in June than the No Action Alternative on average, and the reservoir would be drafted earlier in August. The decrease in the number of days when the reservoir is full during the growing season would result in drier conditions for wetlands and riparian vegetation around the reservoir. The productivity and growth of the narrow band of vegetation at or near high-pool elevation (3,558 to 3,559 feet NGVD29 [NAVD88]) would decrease, or plants would transition to species more tolerant of less water or drier conditions. These changes would result in an overall decrease in the quantity, quality, and distribution of wetland habitats in the narrow band of vegetation adjacent to the reservoir shorelines.

The composition of vegetation in wetland habitats is expected to transition to species more tolerant of dry or drought conditions or may become upland habitat types over time. These changes would result in an overall decrease in the quantity, quality, and distribution of wetland habitats adjacent to the reservoir shorelines in the Hungry Horse study area. Wildlife populations would experience increased risk from predatory animals (i.e., wolf and mountain lion). In response to a loss of wetland habitats and associated vegetation around the reservoir, birds could be displaced from nesting or sheltering habitat in forested and scrub-shrub or emergent herbaceous wetland habitats and would likely relocate to other areas where suitable wetland habitat is available, which could increase competition for limited resources.

In response to a loss of wetland habitats and associated vegetation around the reservoir, birds would be displaced from nesting or sheltering habitat in forested and scrub-shrub or emergent herbaceous wetland habitats adjacent to the reservoir and may be forced to relocate to other areas where suitable nesting habitat is available. This could lead to increased competition for limited resources.

Due to the delay in fill and the earlier drawdown, more of the barren area would be exposed and for longer periods compared to the No Action Alternative. Wildlife would experience increased risk of predation from predatory animals (i.e., wolf, mountain lion, and raptors) in late summer and fall. This would impact individuals but would not have population-level effects for small mammals or the predators.

Implementing MO4 is not expected to result in noticeable changes downstream in the South Fork Flathead River. Water surface elevations during winter and spring would be slightly lower (0.2 to 0.4 feet) than the No Action Alternative, and summer conditions would be slightly higher (0.4 feet). Despite these changes, river conditions would be within the natural range of variability, and any differences are less than 6 inches compared to the No Action Alternative. Vegetation along the river would benefit slightly from more water during the later portion of the growing season. The functional quality of forested and scrub-shrub and emergent herbaceous wetlands would increase slightly as a result of a prolonged period of wetted conditions yielding higher productivity compared to the No Action Alternative. In response, these habitats would provide higher quality breeding, feeding, and sheltering conditions later in the growing season for a suite of wildlife species. Water levels would typically be within a few inches of those in the early part of the growing season under the No Action Alternative. Therefore, these habitats are not expected to transition from one type to another or to experience noticeable changes in plant composition.

Below the confluence of the South Fork Flathead and Flathead Rivers, the effects from implementing MO4 at Hungry Horse would be negligible. Wildlife habitats and populations in the Flathead River would not measurably change from No Action Alternative conditions.

At Albeni Falls Dam, the *McNary Flow Target* measure calls for additional water to be released from Albeni Falls Dam in the late spring and early summer to support fish passage conditions in the Lower Columbia River during drier years. Except as specified below, water surface elevations in Lake Pend Oreille and reaches of the Columbia River downstream of Albeni Falls would be unchanged from No Action Alternative conditions (described in greater detail in Section 3.2, *Hydrology and Hydraulics*). Implementing the *McNary Flow Target* measure would reduce water surface elevations in Lake Pend Oreille during the summer approximately by as much as 2.6 feet in dry years compared to the No Action Alternative; July and August would experience the greatest decrease in pool elevations, with smaller decreases occurring in June and September. The growing season in the Albeni Falls study area occurs from April through October. Because changes occur during the growing season, the habitats most likely impacted by this measure include mudflats, barren zones, and forested and scrub-shrub and emergent herbaceous wetlands, as well as islands with variable habitats. Wildlife species most likely to be affected include waterfowl; shorebirds; small and medium-sized mammals, including beaver and muskrat; amphibians; and insects.

In the drier 50 percent of years, MO4 would expose mudflats and barren lands that are typically covered by water during summer under the No Action Alternative. Exposing these lands between elevations 2,059.7 and 2,062.5 feet NGVD29 (NAVD88) during the growing season would also result in the establishment and growth of emergent and shrubby vegetation, including non-native, invasive plant species (Figure 3-153). Recreational activities on Lake Pend Oreille include boating, which produces wakes that lead to erosion along barren zones and mudflats. In comparison with the No Action Alternative, implementing MO4 would expose an additional 1,200 acres of land to erosion during the summer (Figure 3-154).

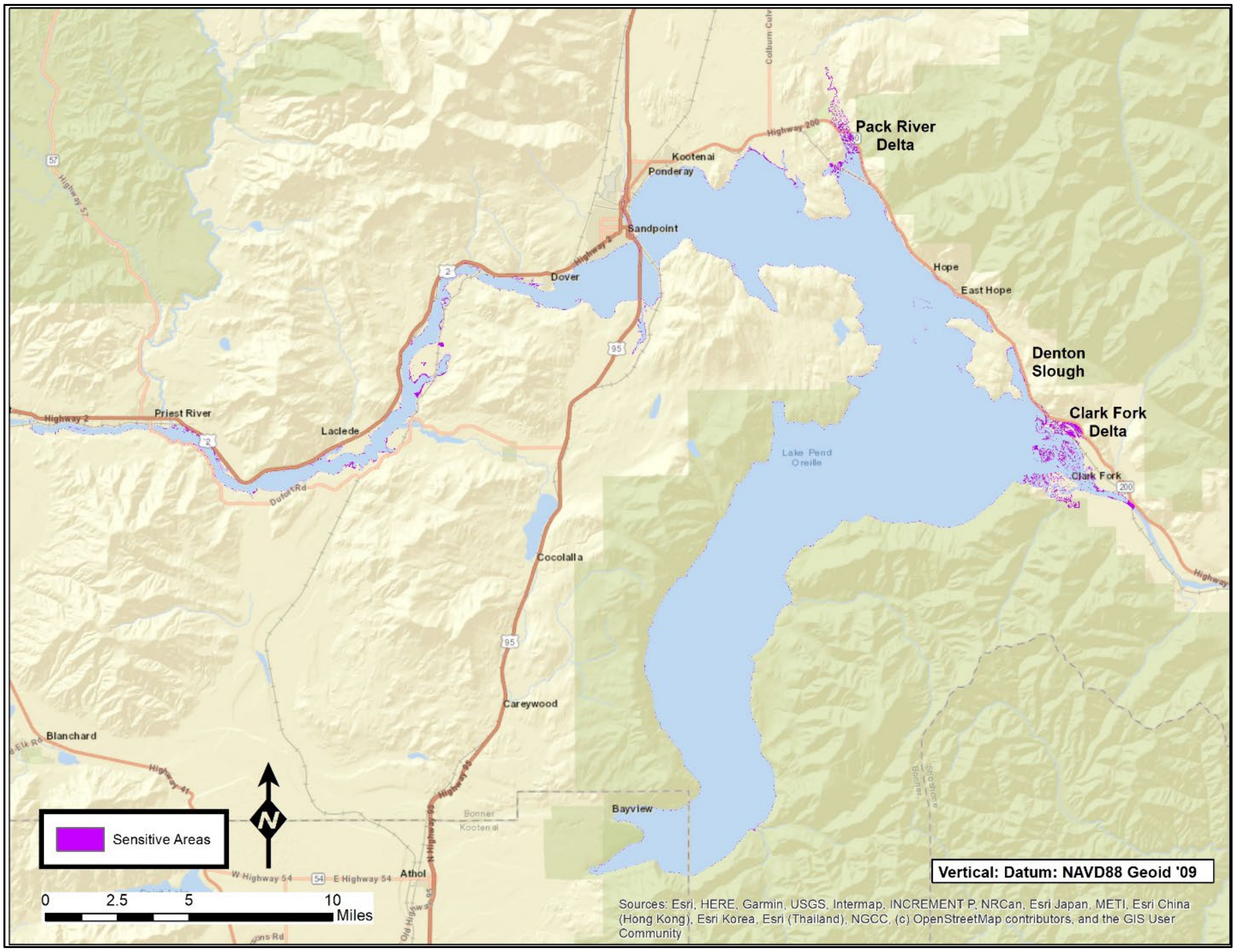


**Figure 3-153. Map Showing Sensitive Areas Along the Lake Pend Oreille Shoreline**

Note: These areas would experience exposed mudflats, conversion of wetland habitats, and extensive barren zones under MO4. These sensitive areas include shorelines within the Pack River Delta, Denton Slough, and Clark Fork Delta.

Lower lake elevations would result in changes to emergent herbaceous and forested and scrub-shrub wetland vegetation similar to the effects described in Region A from implementation of the *McNary Flow Target* measure (Figure 3-155). Increasingly dry conditions would decrease the quantity, quality, and distribution of wetland habitats that occur at the lake shorelines, or these habitats would transition to upland habitat types or change the plant composition compared to current conditions. Conversely, portions of the barren zone would transition to wetland habitats under MO4 where emergent vegetation becomes established because water depths are lower compared to the No Action Alternative. Lower lake levels in the summer months under MO4 would change the quantity and quality of habitats in the Pend Oreille and Farragut WMA lands. Increasing the area of exposed ground would temporarily increase shorebird use of exposed mudflats, as well as shift the composition and distribution of wetland vegetation as habitats stabilize after implementation. Without continued management of these lands, it is highly likely that non-native, invasive plants would colonize exposed portions of the lake shoreline over time, which reduces the overall structural and functional quality of these habitats. The duration of these changes and time it takes for habitats to stabilize following implementation would depend on the frequency and duration of consecutive dry years driving lower lake levels.


**Figure 3-154. Shorelines of Denton Slough in Lake Pend Oreille Showing Average Land Exposure for the No Action Alternative and MO4**

Note: An additional 1,200 acres of exposed land would occur under MO4 in comparison with the No Action Alternative (elevations highlighted in gray, yellow, and orange).

The composition of vegetation in wetland habitats is expected to transition to species more tolerant of dry or drought conditions or may become upland habitat types over time. These changes would result in an overall decrease in the quantity, quality, and distribution of wetland habitats adjacent to the reservoir shorelines in the Hungry Horse study area. Wildlife populations would experience increased risk from predatory animals (i.e., wolf and mountain lion). In response to a loss of wetland habitats and associated vegetation around the reservoir, birds could be displaced from nesting or sheltering habitat in forested and scrub-shrub or emergent herbaceous wetland habitats and would likely experience increased competition in remnant wetland habitats, if not leaving the area altogether. Ultimately, they may die off for a lack of similar, unoccupied habitats.

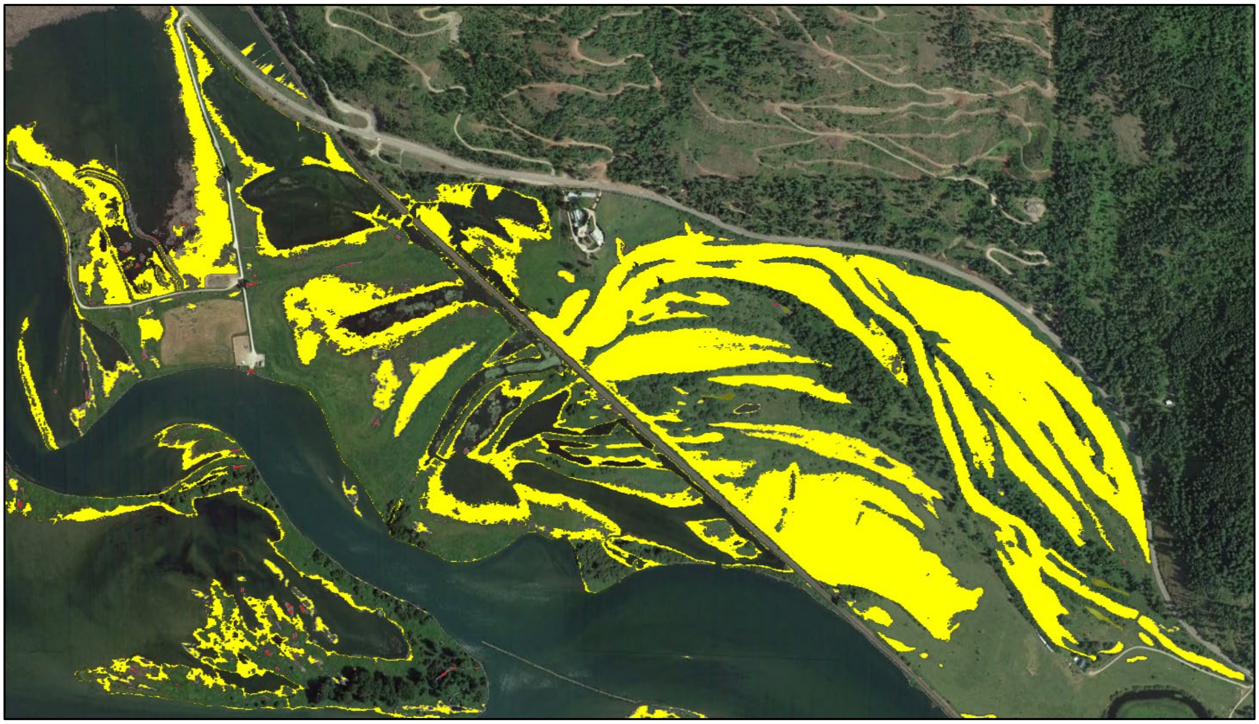

**Figure 3-155. Wetlands within the Clark Fork Delta on Pend Orielle Lake**

Wildlife dependent upon wetland habitats would disperse to other areas where suitable habitat exists. In these situations, wildlife would experience temporary displacement and increased competition for limited resources until the system reaches an equilibrium as habitat stabilizes following implementation. In other instances, wildlife may forego breeding or experience reduced productivity for several years until suitable breeding habitat is available. For example, lower pool elevations may force beaver and muskrat to relocate to different locations within the study area where sufficient material is available for the construction of lodges and forage material. Under lower lake levels, the quantity, quality, and distribution of wetland habitats would decrease, resulting in parallel declines in species entirely dependent upon these habitat for all or part of their life cycles, including amphibians and insects, which support the food web and serve as prey resources for other animals, including birds, bats, and fish.

The structure and function of wetland habitats in Lake Pend Oreille could change under lower lake levels and thus alter the quality and availability of nest materials for western grebes. These changes would affect nest quality, which could subsequently increase the vulnerability of nests, eggs, and young birds to predators. If nests are constructed in emergent herbaceous wetlands and then float into the main part of the reservoir, they would experience increased exposure to motorized boat traffic. Denton Slough provides a safe harbor for nesting Western grebes because it is shallow (Hull 2019). Nests could be pulled into the main portion of the reservoir and therefore would experience higher mortality due to increased exposure to weather conditions, which would result in decreased reproductive success over time. Similarly, the reproductive success of ground-nesting waterfowl could decrease if the birds experience higher rates of mortality from predation and exposure, as nests are located farther from the shoreline in lower quality habitats. On the other hand, lower pool elevations would increase the area of barren zones and mudflats supporting breeding and migratory shorebirds that forage on benthic invertebrates in the mud.

Implementing the *McNary Flow Target* measure would increase water surface elevations on the Pend Oreille River downstream of Albeni Falls during the summer in average and low water events. The increase in water surface elevations would range between 6 and 8.5 inches compared to the No Action Alternative, and the difference decreases further downstream (see Section 3.2, *Hydrology and Hydraulics*, for greater detail). Because these changes are within the natural range of variation in the river across different water events, the increased river levels are not expected to change the quantity, distribution, or composition of habitats along the river relative to the No Action Alternative. However, MO4 could make wetland habitat available more frequently due to more frequent inundation. Therefore, MO4 may result in higher quality breeding, feeding, and sheltering conditions during the growing season and improve wildlife habitats and populations downstream of Albeni Falls.

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

No structural measures would be implemented in Region B under MO4, and therefore, the proposed structural measures would not impact floodplains, wildlife habitats, or populations. As described in Chapter 2, MO4 includes implementing seven operational measures in Region B: *McNary Flow Target*; *Update System FRM Calculation*; *Planned Draft Rate at Grand Coulee*; *Grand Coulee Maintenance Operations*; *Winter System FRM Space*; *Lake Roosevelt Additional Water Supply*; and *Chief Joseph Dam Project Additional Water Supply*. Collectively, these measures would influence operations in Region B by supporting downstream FRM, decreasing draft rates, and increasing diversions for water supply and irrigation. Implementing the *Update System FRM Calculation* and *Grand Coulee Maintenance Operations* measures influence operation of Grand Coulee by increasing operational flexibility of the dam and improving capacity during ongoing operations and maintenance actions similar to MO1.

Shallow backwater habitat would become intermittently dry as water surface elevations decrease, causing immotile amphibian eggs like those of the western toad to desiccate. Because of the lack of vegetation or other habitat cover in the barren zone, small mammals (i.e., mice, voles, and shrews) would experience increased rates of predation, as they would be more susceptible to predators foraging along the reservoir shoreline. Areas that establish as emergent herbaceous wetlands would provide increased protection for some animals, as well as increasing overall biodiversity and productivity along the reservoir.

For floodplains, annual average probability of inundation is expected to remain unchanged from current conditions in Region B, with negligible effects.

Grand Coulee would be operated to support FRM operations in the lower Columbia River by implementing the *Winter System FRM* measure and support fish passage conditions in the lower Snake and Columbia Rivers by implementing the *McNary Flow Target* measure. In the dryer 40 percent of water years, May through August water levels under MO4 could be 10 to 20 feet lower than No Action Alternative due to the *McNary Flow Target* measure, and the Lake would not reach the full elevation of 1,290 feet NGVD29 in about half of all years. See Chapter 3.2, Hydrology and Hydraulics, for more detailed discussion of Lake Roosevelt water level changes. As a result, MO4 would effectively expose a larger barren zone in the elevation range of 1,260 feet to 1,280 feet NGVD29, which is used to getting wet every years for most of the year but is now going to be inundated less frequently. This would decrease the quantity, quality, and distribution of emergent herbaceous and forested and scrub-shrub wetland habitats adjacent to the shoreline in low-lying, shallow areas. The typical growing season in the Grand Coulee study area is April through October. Since pool elevations would be lower during the majority of the growing season, wetland habitats would experience prolonged periods of dry conditions, which would result in a shift in plant composition to species more tolerant of dry or drought conditions, or wetland habitats would transition to upland habitat types.

Lake Roosevelt has the potential to be a crossing or migration corridor for large mammals, peak active season for these species in this area is from May through September. Habitat around Lake Roosevelt is traditional winter range habitat for big game with winter peak use from November through April. During the peak active season for these terrestrial mammals, water surface elevation levels would be lower than existing conditions and the No Action Alternative. This would have a moderate effect on migration of these species.

Implementing the *Lake Roosevelt Additional Water Supply* measure at Grand Coulee and the *Chief Joseph Dam Project Additional Water Supply* measure at Chief Joseph support increased diversion of water from Lake Roosevelt and the Columbia River for irrigation and municipal and industrial uses between April and November. The winter FRM and adjustments for McNary flows have the largest effects on water surface elevation levels in Lake Roosevelt, while the water supply measure affects changes in outflow. These combined changes are expected to contribute to reductions in pool elevations in Lake Roosevelt upstream of Grand Coulee and decreased water surface elevations in the Columbia River downstream from Chief Joseph. The typical growing season at Chief Joseph is similar to Grand Coulee but lasts until November. Water withdrawal for irrigation overlaps with the growing season for both project areas, further reducing the water available for habitats adjacent to the river and lake shorelines. Downstream of Chief Joseph, the change in water surface elevation is typically less than 3 inches, and this amount is expected to be consistent with natural range of variation and is not measurably different than the No Action Alternative. As a result, changes in water surface elevations downstream of Chief Joseph would have negligible effect on wildlife habitat and populations within the Chief Joseph study area. Under MO4, there would be negligible effects to floodplains in Region B because changes in flood elevations would typically be less than 0.3 feet.

In regard to potential effects in Canada, the effects to vegetation and wildlife resources and their habitats under MO4 are expected to be similar to the effects described for the United States portion of Region B

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

Structural measures are *Additional Powerhouse Surface Passage*, *Lower Granite Trap Modifications*, *Lower Snake Ladder Pumps*, *Bypass Screen Modifications for Lamprey*, *Lamprey Passage Ladder Modifications*, and *Spillway Weir Notch Inserts*. These structural measures are not expected to result in widespread effects to floodplains, wildlife habitats, or populations.

MO4 includes operational measures at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. No operational changes would occur at Dworshak under MO4, and consequently, there would be no changes in reservoir levels or dam outflow that would affect wildlife habitats or populations along the Clearwater River upstream of the confluence with the Snake River. Operational measures for Region C include *Spill for Adult Steelhead*, *Spill to 125% TDG*, *Contingency Reserves in Fish Spill*, *Spring & Fall Transport*, *Drawdown to MOP*, and *Above 1% Turbine Operations*. Annual average probability of inundation is expected to remain unchanged from current conditions in Region C, with negligible effects on floodplains.

Under MO4, the reservoir elevations at the four lower Snake River dams would have an adjusted minimum operation pool (MOP) operation from March 15 through August 15 due to the *Drawdown to MOP* measure. At all four projects, the seasonal MOP range is increased from a 1.0-foot range to a 1.5-foot range, each with a 0.5-foot increase in the upper end of the range. Annual average probability of inundation is expected to remain unchanged from current conditions in Region C, with negligible effects on floodplains.

Overall, wetland habitats would be wetter for longer time periods under MO4 compared to the No Action Alternative. Given these changes in river levels on the Snake River, forested and scrub-shrub wetlands would experience increased inundation in low-lying areas during the majority of the growing season. Woody vegetation is inundated for prolonged periods or with increased frequency compared to the No Action Alternative; this vegetation would convert to emergent plant species more tolerant of wet conditions.

Conversely, because pool elevations would be higher along the Snake River during the spring and summer months compared to the No Action Alternative, there may be an increased quantity, quality, and distribution of wetted areas and off-channel pools along the river shorelines. These wetted areas support breeding habitats for wetland-dependent amphibians, such as the western toad and northern leopard frog. Similar to potential increases in water surface elevation on the lower Flathead River, vegetation along the Snake River could benefit from slightly more water in the river throughout the growing season. The overall quantity and functional quality of forested and scrub-shrub and emergent herbaceous wetlands would increase as a result of a prolonged period of wetted conditions, yielding higher productivity compared to the No Action Alternative. In response, these habitats would provide higher quality breeding, feeding, and sheltering conditions for a suite of wildlife species. For example, wetted areas along the riverbanks provide habitat for amphibians to lay eggs, and maintaining wetted conditions through the summer provides adequate habitat for tadpoles to grow and develop before pools dry up and shrink later in the summer. While the potential increase in water depth is not substantial (less than 4 inches), it may be sufficient to provide additional habitat for these species.

As a result, there would be some effects to wildlife populations using these habitats. For example, the overall quantity and quality of habitat for ground-nesting birds, such as harlequin duck that breed along well-concealed streambanks or on islands between Silcott Island and Ice Harbor, would decrease. Additionally, if some woody vegetation transitions to emergent vegetation over time, the amount of nesting habitat for birds such as veery or warblers that nest in wetland thickets may decrease. In these circumstances, birds may be forced to relocate to other areas where suitable nesting habitat is available, which could increase competition for limited resources.

The *Spill to 125 percent TDG* measure would increase the proportion of juvenile fish migrating in river because fewer fish will be transported. For example, it is estimated that the proportion of juvenile Snake River steelhead transported would decrease from 38.5 percent under the No Action Alternative to 7.3 percent under MO4. More juvenile fish migrating in the Snake and Columbia rivers would mean increased prey availability for fish eating birds and mammals.

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

Structural measures associated with MO4 in Region D are *Additional Powerhouse Surface Passage*, *Improved Fish Passage Turbines*, *Lamprey Passage Structures*, *Lamprey Passage Ladder Modifications*, and *Spillway Weir Notch Inserts*. These structural measures are not expected to result in widespread effects to wildlife habitats or populations.

Under MO4, there would be changes to the reservoir elevations at McNary, John Day, The Dalles, and Bonneville Dams. All would have an adjusted operating range because of the *Drawdown to MOP* measure, which results in a decreased operating range from March 25 through August 15. McNary Dam would operate approximately 2 feet lower in operating range from the No Action Alternative. John Day Dam would operate approximately 1.5 to 2.5 feet lower than No Action Alternative. The Dalles Dam would operate 3.5 feet lower than the No Action Alternative. Bonneville Dam pool would operate 3.5 feet lower than the No Action Alternative.

Operational measures associated with MO4 are *Spill for Adult Steelhead*, *Spill to 125% TDG*, *Contingency Reserves in Fish Spill*, *Drawdown to MOP*, and *Above 1% Turbine Operations*. Implementing the *Drawdown to MOP* measure would have effects on wildlife habitats and populations in Region D as a function of decreased pool elevations on the lower Columbia River above Bonneville Dam during the growing season. See Section 3.2, *Hydrology and Hydraulics*, for greater detail on changes to annual and monthly hydrology. There are no changes in pool elevations or river conditions outside of the growing season and, as a result, changes to wildlife habitats and populations would be the result of changes occurring during the growing season. Reductions in the annual average probability of inundation could cause minor to moderate effects on floodplains.

Under these conditions, forested and scrub-shrub and emergent herbaceous wetland habitats would dry out, causing a widespread decrease in the quantity, quality, and distribution of these habitats in Region D. Additionally, the plant composition in wetland habitats would transition to upland plant species more tolerant of dry conditions, further reducing the availability and distribution of wetland habitats for wildlife on the lower Columbia River. There are several state and federal wildlife managed areas that could be impacted by this measure, including the McNary NWR, Umatilla NWR, Irrigon WMA, and Klickitat WMA. In addition to these locations, areas that are not managed specifically for wildlife but provide valuable habitat for a multitude of species would be impacted, including the Yakima River delta, Badger Island, the Walla Walla River delta upstream of McNary, the Umatilla IBA in Lake Umatilla, and Miller Rocks in Lake Celilo. Badger Island and Foundation Island would expand by 50 to 60 percent and 800 to 900 percent, respectively, under MO4, beyond No Action Alternative conditions. These areas would expand the area of potential wetland habitats or become exposed mudflats (Figure 3-156). At Umatilla NWR, wetlands or exposed mudflats would expand by as much as 130 to 140 percent.

Under MO4, portions of the shoreline that are inundated under the No Action Alternative would be exposed during the growing season, and shallow open water habitats would transition to exposed mudflats. As invertebrate communities become established in the years following implementation, these areas would attract wading birds, such as herons and egrets, as well as shorebirds that forage on the exposed sediments. In addition to increasing the quantity and distribution of exposed shorelines for foraging habitat, the exposed sediments would increase the quantity and distribution of nesting habitats for ground-nesting colonial waterbirds, including Caspian tern, double-crested cormorant, gulls, and pelicans. Region D includes notable breeding colonies of these birds at several locations, and implementing MO4 would increase the availability of suitable habitat for these birds, which would support increased population growth if food resources were available to support nesting birds and fledglings. At Blalock Islands, the relative proportion of habitat available to nesting waterbirds under MO4 would increase by 120 percent and expand to approximately 8.0 acres compared to the amount available under the No Action Alternative, which is approximately 3.6 acres. In 1976, Asherin and Claar found that decreased water surface elevations in the McNary pool exposed land bridges to Badger and Foundation islands—as well as three of the five Hat Islands—and coyote predated goose nesting on these islands (Asherin and Claar 1976). Conversely, if the islands were effectively isolated from the mainland and terrestrial predators, island habitat would be more suitable for nesting waterfowl.

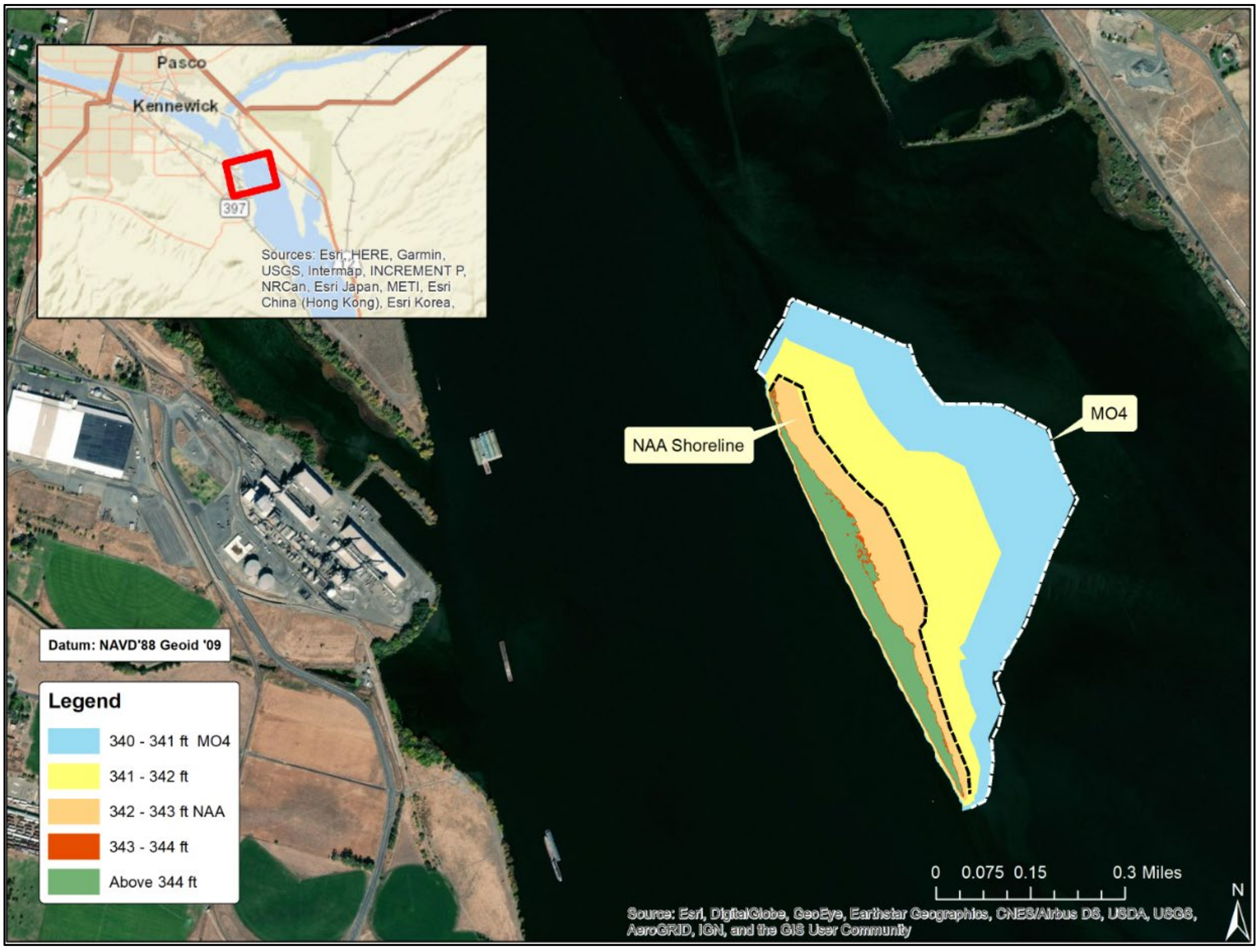


**Figure 3-156. Foundation Island in McNary Pool**

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.

Following implementation of MO4 and lower water levels in the reservoirs, wetland habitats upstream of Bonneville Dam could transition to upland habitat types over time as the composition of plants shifts to species more tolerant of drier conditions. Given the extent of rocky shorelines throughout the lower Columbia River, there is limited potential for wetlands to establish at lower elevations. Therefore, forested and scrub-shrub and emergent herbaceous wetlands and off-channel habitats could convert to drier habitat types, decreasing the overall quantity, quality, and distribution of regionally important wetlands in upper reaches of Region D. Wetland function would decrease, and overall productivity of these habitats would subsequently decrease, resulting in widespread effects on the availability of food resources for resident and migratory wildlife. The McNary and Umatilla NWRs and Umatilla IBA provide critical wintering habitat for tens of thousands of ducks and geese in the Pacific Flyway. Decreasing the quantity and quality of these important wetland habitats would have substantial effects on these birds by causing them to relocate to more favorable overwintering habitat, and potentially reducing population fitness and decreasing survival of young birds and females for overwintering birds that continue to overwinter in these two refuges.

Changes to the quantity, quality, and distribution of wetland habitats in upper portions of Region D would also impact amphibians, migratory songbirds, and mammals. Western toads and northern leopard frogs breed in pools and slow-moving waters. If wetland habitats desiccate and shrink in response to the *Drawdown to MOP* measure, a lack of breeding pools and wetted conditions would be detrimental to the survival of amphibian egg masses and tadpoles. Similar to the potential effects to waterfowl, decreasing survival of amphibians in these areas would influence overall productivity of the population, and where populations are declining, these trends would continue or increase. Furthermore, as woody vegetation changes under drier conditions or becomes stressed under prolonged periods of drought, the suitability or quality of breeding habitats would decrease and increase competition for habitat where it occurs. Fawning habitat would decrease if the quality of wetland habitats decreases to the point that insufficient cover and shelter is available for juvenile deer to hide in while adults forage nearby. If tree cover decreases because river conditions no longer support wetland-dependent vegetation, nesting habitats for woodpeckers, raptors such as eagles, falcons and hawks, and migratory songbirds would decrease. As a result, birds would be displaced to areas with suitable habitats, increasing competition for limited resources.

Actions currently implemented under the No Action Alternative that are expected to continue under MO4 include efforts to reduce the spread and establishment of invasive species throughout Region D. Decreasing pool elevations between McNary and Bonneville Dams in response to the *Drawdown to MOP* measure could result in a widespread increase in the distribution and establishment of invasive species as they spread into areas where they do not occur under the No Action Alternative. As a result, the overall distribution and quantity of invasive species in Region D could increase under MO4, which would reduce habitat quality for a suite of wildlife. Where no management efforts are implemented, invasive species are expected to persist under MO4, similar to the No Action Alternative.

Reductions in the annual average probability of inundation could cause minor to moderate effects on floodplains. Minor reductions in flood elevations would occur below Bonneville Dam for floods that occur with moderate frequency, which could have minor effects on floodplain benefits in this region. On average, changes in river levels downstream of Bonneville Dam would be less than 3 inches and within the natural range of variability in daily water levels. For this reason, MO4 is not expected to cause measurable effects to wildlife populations or their habitats downstream of Bonneville Dam. The lower portions of the Columbia River would continue to support valuable habitat for fish and wildlife, and current trends are expected to continue.

Decreasing pool elevations under the *Drawdown to MOP* measure increases survival of juvenile salmonids by decreasing downstream travel times. Refer to Chapter 3.5 for specific effects on anadromous fish species. Furthermore, the *Spill to 125 Percent TDG* measure results in fewer juvenile salmon and steelhead collected and transported to downstream of Bonneville Dam. As such, this measure effectively provides an increase in prey resources between the confluence of Snake and Columbia Rivers and Bonneville Dam. Fish are also anticipated to move through the system faster as a result of these measures, which may increase their ocean survival and adult fish return rates.

**FLOODPLAINS**

Under MO4, changes in flood elevations would typically be negligible (absolute value less than 0.3 feet) across the Columbia River Basin for all flood frequencies, from regularly occurring floods (AEP of 50 percent) to the base flood (AEP of 1 percent). Moderate decreases in flood elevations (absolute value less than 1.5 feet) are predicted in Region D for Bonneville Reservoir, and minor reductions in flood elevations (absolute value less than 1 foot) are predicted in Region D for the upper part of Lake Celilo Reservoir (for floods with AEP values from 50 to 2 percent) and for the Columbia River below Bonneville Dam for floods with moderate frequencies (AEP values from 15 to 5 percent). Based on these results, the annual average probability of inundation would remain unchanged from current conditions in most of the basin, with minor reductions in inundation frequency in the lower Columbia River below John Day Dam. These changes could have minor effects on floodplain benefits in the affected regions.

**SPECIAL STATUS SPECIES**

This section discusses the potential effects of implementing MO4 on ESA-listed plant and animal species that may occur in the study area.

Table 3-107 provides details about ESA-listed wildlife species that are known or likely to occur in the study area and the potential effects to these species or their critical habitats in response to MO4 implementation. Similar to the No Action Alternative, it is assumed that those species listed under the Endangered Species Act and present in the study area will remain listed, and existing regulatory and best management practices would reduce the likelihood that populations would continue declining or become extinct. It is assumed that neither grizzly bear critical habitat nor whitebark pine would be listed, and their presence and population in, or in the vicinity of, the study area would remain relatively stable.

According to the modeling conducted for fish survival and passage in Section 3.5, the CSS model predicts a major increase in adult returns, while National Marine Fisheries Service predicts a decrease in adult returns. Therefore, numbers of returning salmon runs are uncertain and could increase or decrease as a result of MO4. These return rates mean that effects to marine mammals, such as sea lion and Southern Resident killer whale, are also uncertain. There may be a negligible benefit or negligible detriment to these species. Consequently, MO4 would not cause a decrease or increase in the population of Southern Resident killer whale, California sea 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 | *Ursus arctos horribilis* | ESA status: T<br>CH: Proposed | Libby<br>Hungry Horse | **Construction of structures on the dams:** No effect. Bears are spatially removed from dams.<br>**Hydrology:** Negligible effect. Hydrograph would be beneficial to establishment of cottonwood seedlings. Benefit to riparian species.<br>**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 | *Odocoileus virginianus leucurus* | ESA status: T<br>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.<br>**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.<br>**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 | *Zalophus californianus* | ESA status: None<br>CH: None<br>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.<br>**Prey availability:** Negligible effect. Fish models predict a negligible increase or decrease in available prey.<br>**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 | *Eumetopias jubatus* | ESA status: None<br>CH: None<br>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.<br>**Prey availability:** Negligible effect. Fish models predict a negligible increase or decrease in available prey.<br>**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 | *Orcinus orca* | ESA status: E<br>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.<br>**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.<br><br>**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 | *Coccyzus americanus* | ESA status: T<br>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.<br>**Hydrology:**<br>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 (*Winter Stage for Riparian* measure) may equate to increased acreages of suitable habitat for the western yellow-billed cuckoo.<br>**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 | *Haliaeetus leucocephalus*<br>*Aquila chrysaetos* | Bald and Golden Eagle Protection Act | Throughout the study area. | **Construction of structures on the dams:** No effect.<br>**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.<br>**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 | *Eremophila alpestris strigata* | ESA status: T<br>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.<br>**Hydrology:** No effect. Virtually no change in water surface elevation below RM 123. Not likely to convert suitable habitat or flood individuals.<br>**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 | *Spiranthes diluvialis* | ESA status: T<br>CH: None | Grand Coulee<br>Chief Joseph | **Construction of structures on the dams:** No effect. Disturbance would not extend to suitable habitat, no individuals or habitat affected.<br>**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.<br>**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. |

Note: C = Candidate for listing; CH = Designated Critical Habitat; E = Endangered; T = Threatened.

**SUMMARY OF EFFECTS**

Ongoing actions for impacts to vegetation and wildlife in Regions A, B, C, and D would continue, including protection, mitigation, and enhancement of wildlife habitat as discussed in Section 5.2.1. The effect of MO4 could be summarized by region, as follows.

In Region A, under MO4, changes to available wildlife habitat, wetlands, and vegetation would occur in Lake Koocanusa and the Kootenai River. The average annual drop in surface water elevations in the Kootenai River would alter wetland types along the riverbanks and riparian areas. These fluctuations would inundate narrow bands of emergent vegetation and wetlands along the Kootenai River shoreline during the growing season and could result in a minor change on wildlife usage. In Lake Koocanusa, the quantity of barren area around the lake would decrease under MO4, allowing for more potential vegetation establishment around the margins of the lake which would have a minor beneficial effect on wildlife that access the lake.

Further, MO4 would alter Hungry Horse water surface elevations and outflows and the subsequent effects on vegetation and habitat. The decrease in the number of days when the reservoir is full during the growing season would result in drier conditions for wetlands and riparian vegetation around the reservoir. These changes would result in an overall decrease in the quantity, quality, and distribution of wetland habitats for certain wildlife in the narrow band of vegetation adjacent to the reservoir shorelines. In the drier 50 percent of years, MO4 would expose mudflats and barren lands that are typically covered by water during summer in Lake Pend Oreille under the No Action Alternative. Overall, for Region A, there would be a moderate effect on wetlands, vegetation, habitat, and wildlife under MO4, although the annual average probability of inundation is predicted to remain unchanged from current conditions.

In Region B, pool elevations in Lake Roosevelt would be lower during the winter, spring, and summer months. Because pool elevations would be lower during the majority of the growing season, wetland habitats would experience prolonged periods of dry conditions, which would result in a shift in plant composition to species more tolerant of dry or drought conditions, or wetland habitats would transition to upland habitat types. MO4 would effectively increase the barren zone around the lake and change patterns of inundation to the extent that emergent wetland and scrub-shrub wetlands would be reduced. These changes are anticipated to have minor adverse effects on quantity or distribution of wildlife habitat. Implementing the *Planned Draft Rate at Grand Coulee* measure would decrease sloughing or landslides in the winter and early part of the growing season. Changes in water surface elevations downstream of Chief Joseph Dam would have negligible effects on wildlife habitat and populations within the Chief Joseph study area. Annual average probability of inundation would remain unchanged from current conditions in Region B. Overall, for Region B, there would be a minor adverse effect on wetlands, vegetation, habitat, and wildlife under MO4.

In Region C, river and pool elevations would be higher along the Snake River during the spring and summer months compared to the No Action Alternative, there may be an increased quantity, quality, and distribution of wetted areas and off-channel pools along the river shorelines. These wetted areas support breeding habitats for wetland-dependent wildlife species. Overall, for Region C, there would be a negligible effect on floodplains, wetlands, vegetation, habitat, and wildlife under MO 4.

In Region D, implementing the *Drawdown to MOP* measure would have effects on wildlife habitats and populations as a function of decreased pool elevations on the lower Columbia River above Bonneville Dam during the growing season. Moderate decreases in elevations would occur in Bonneville Reservoir, with minor reductions for the upper part of Lake Celilo Reservoir. Under these conditions, forested and scrub-shrub and emergent herbaceous wetland habitats could dry out, causing a widespread decrease in the quantity, quality, and distribution of these habitats in Region D. Additionally, the plant composition in wetland habitats would transition to upland plant species more tolerant of dry conditions, further reducing the availability and distribution of wetland habitats for wildlife on the lower Columbia River. Associated with this transition, MO4 could increase the availability of suitable habitat for ground nesting birds, which could support increased population growth if food resources are available. Overall, for Region D, there would be minor impacts to floodplains below John Day Dam, and a moderate effect on wetlands, vegetation, habitat, and wildlife under MO4.

For special status species in all regions, multiple special status species would be impacted by MO4 beyond No Action Alternative conditions. Grizzly bear may slightly benefit from an enhanced riparian system downstream of Libby Dam. Riparian vegetation may produce more berries, a food source for grizzly bear. Columbian white-tailed deer may experience a negligible effect from MO3. California sea lion and Steller sea lion may experience a negative effect because of temporary construction activities at Bonneville Dam. However, this effect should be temporary and negligible. Yellow-billed cuckoo habitat may be slightly affected by changes in hydrology. This effect is considered negligible. Bald eagle habitat may be slightly affected by changes in hydrology. This effect is considered negligible. Ute ladies'-tresses may be slightly affected by changes in hydrology. This effect is considered negligible. Overall, there would be a low impact on most special status species.

### 3.6.4 Tribal Interests

Plants and animals are important to tribes throughout the Columbia River Basin. They are used for subsistence, ceremonies, medicines, art, clothes, and items of everyday use. They play fundamental roles in diet, materials, and spiritual practices. Tribal traditional ecological knowledge relies upon a holistic perspective of humans, ecosystems, economies, and cultures for the use of plants and animals.

Changing hydrology can impact vegetation, plant communities, and wildlife. The primary effects to vegetation, wetlands, floodplains, and wildlife, as described above in Section 3.6.3 under the action alternatives, relate to changing water surface elevations below projects and changing reservoir levels that result in more frequent or extensive exposure of the barren area surrounding storage reservoirs. In Regions A and B, changes to water surface elevations may cause wetland habitats to shift slightly, or they may convert to drier habitat types. Wetlands may shift up or down, and increase or decrease in size, depending on location and water levels. Individual plants that are important for traditional uses, such as cottonwood, wapato, or tule, may be lost in isolated areas or their range may expand—it depends on the plant, location, depth of water, changes in hydrology, soil moisture, and other growing conditions. Any loss or changes, however, would not result in population level effects or benefits because: the effects would be isolated to a narrow band adjacent to rivers and reservoirs; the impacted areas are generally small relative to the overall watersheds or reaches they are located in; and there are seed or root sources available for re-colonization if individuals are lost. Furthermore, changes in habitats may benefit some traditional-use plants.

The biggest change to vegetation and wetlands would come under MO3 along the Snake River from Lower Granite Dam to McNary Dam because of dam breaching. There would be substantial changes in plant communities at least for the short term (up to 10 years) depending on successful mitigation. After dam breach, newly exposed streambanks, and benches would be devoid of vegetation. Existing wetland habitat would convert to drier vegetation types, and there would be increased potential for exposed areas to be colonized by invasive species. Willow communities currently along the riverbanks would likely be perched, may lose connectivity with groundwater, and could die in the short term. Plant communities along this long reach of the Snake River may shift to those more tolerant of dry conditions that can do with less soil moisture. Traditional-use plants that are emergent wetland species would be lost in areas impacted by dam breaching, unless they are part of the replanting effort. However, like in Regions A and B, these areas would be isolated, and other locations outside the floodplain would not be impacted. Mitigation proposed under MO3 includes measures to replant the area with appropriate species for soil conditions. Mitigation would ameliorate the effects described above to an extent, and areas would benefit greatly by replanting and would shorten the timeframe for adverse effects to less than 60 years.

# 3.7 POWER GENERATION AND TRANSMISSION

## 3.7.1 Introduction and Background

Bonneville is a Federal power marketing administration designated by statute to sell power and transmission services throughout the Pacific Northwest region. Bonneville sells electric power from CRS projects, operated and maintained by the Corps and Reclamation, to its regional firm power customers across the Pacific Northwest, including municipalities, public utility districts (PUDs), cooperatives, Federal agencies, direct service industries (DSIs), and investor-owned utilities (IOUs). These wholesale power customers either use the power directly or resell electricity to residential, commercial, and industrial retail customers (i.e., "end users").

Bonneville also operates and maintains about 15,000 circuit miles of the high-voltage transmission system within the Pacific Northwest region (Bonneville 2018a). This system integrates and transmits electric power within the Pacific Northwest region and interconnects with external transmission systems throughout the western United States and parts of Canada and Mexico. Separate from its power sales, Bonneville sells transmission services (for the delivery of electricity from generating resources to end users) and associated ancillary services (for maintaining transmission system reliability) to regional firm power customers, independent power producers, and power marketers.

The MOs have the potential to affect the availability of power to meet regional demand, as well as the flow of power across the transmission system. Together, these changes could affect costs for both power and transmission services, wholesale and retail rates, and, ultimately, regional and local economies.

### *3.7.1.1 Statutory Framework*

Bonneville was created by Congress through enactment of the Bonneville Project Act in 1937, Pub. L. No. 75-329, 50 Stat. 731 (codified as amended at 16 U.S.C. §§ 832-832m (2012)) to market and transmit electric power produced by Federal hydropower dams in the Pacific Northwest. Bonneville's authority to market power generated from the entire Federal Columbia River Power System[1] (FCRPS), of which the Columbia River System hydropower dams are a subset, is codified in Section 8 of the Federal Columbia River Transmission System Act of 1974, Pub. 93-454, 88 Stat. 1376, (codified as amended at 16 USC §§ 838-838l (2012)). The Federal Columbia River Transmission System Act also gave Bonneville express authority to operate and maintain the Federal Transmission System within the Pacific Northwest and to construct improvements, betterments, and additions to and replacements of the system. The terms and rates upon which Bonneville may sell power and transmission services are subject to several statutes, including the Bonneville Project Act, the Flood Control Act of 1944, Pub. L. No. 78-534, 58 Stat. 887 (codified at 16 U.S.C. § 825s (2012)), the Federal Pacific Northwest Consumer 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.

837h (2012)), the Federal Columbia River System Transmission Act of 1974, and the Pacific Northwest Electric Power Planning and Conservation Act, 1980, Pub. L. No. 96-501, 94 Stat. 2697 (codified at 16 U.S.C. § 839-839h (2012)).

#### *3.7.1.2 Historical Context*

Beginning in 1937, Bonneville first marketed the power from the Bonneville dam and began the construction of transmission systems to extend delivery of Federal power to purchasers throughout the Pacific Northwest. With the addition of each Federal dam, hydroelectric power from Federal projects could be generated at very low costs compared to other power resources, such as IOU's resources. The Bonneville Project Act's rate directives allowed for the setting of uniform rates to extend the benefits of the low-cost Federal power system as widely as possible, including remote, rural communities. The uniform rates are also known as "postage stamp rates," in references to the concept that postage stamps ensure mail delivery across the street or across the nation at a posted uniform rate. As such, Bonneville broadened the reach of Federal power by constructing transmission to deliver Federal power to sparsely populated and rural areas. In turn, PUDs and rural electric cooperatives were encouraged to form and request Federal power from Bonneville to serve their customer base.

#### *3.7.1.3 Area of Analysis*

The areas of analysis for the power and transmission resources are different because of the nature of the services and products. Both the power and transmission analyses are focused on the Bonneville service area shown in Figure 3-157 and are not split into the four CRSO analysis regions used in the EIS given the interrelated nature of the systems across these regions. Bonneville's service area is defined by the Northwest Power Act as the Pacific Northwest, which includes Oregon, Washington, Idaho, the portion of Montana west of the Continental Divide, and the portions of Nevada, Utah, northern California, and Wyoming within the Columbia River drainage basin ("Bonneville's Service Area").[2] However, because Bonneville regularly markets its surplus power both within and outside the Pacific Northwest, the power analysis additionally considers potential effects on the power markets within the larger Western Interconnection area (Figure 3-158).

For additional discussion on potential effects to areas outside of the Pacific Northwest, see Section 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*.

[2] 16 U.S.C. § 839a(14) (2018).

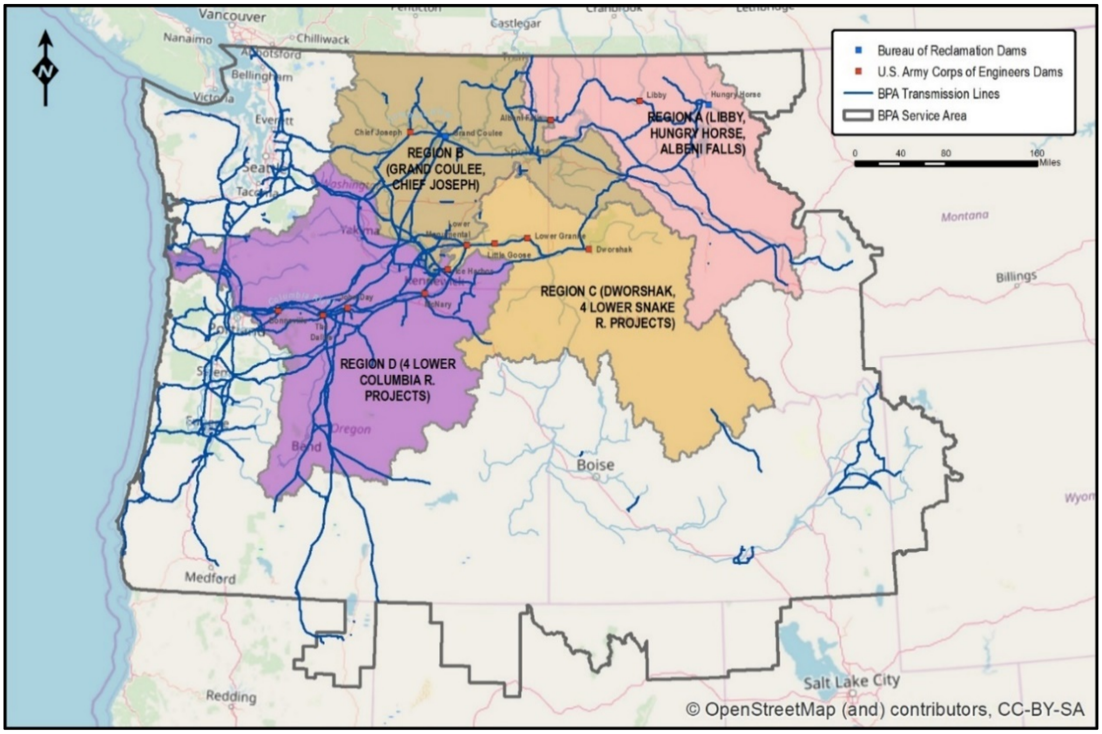


**Figure 3-157. Transmission Area of Analysis – the Bonneville Service Area and Transmission Lines**

Source: Bonneville (2018a)

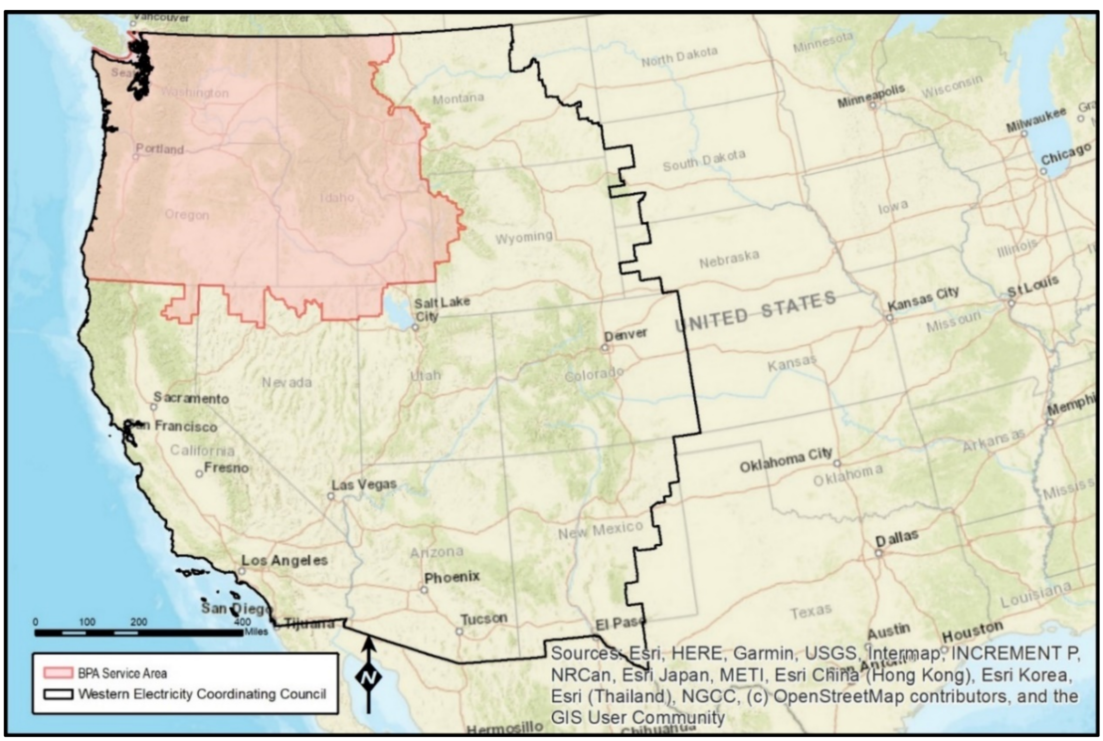


**Figure 3-158. Power Area of Analysis – the U.S. Portion of the Western Interconnection and the Bonneville Service Area**

Source: Bonneville (2018a); WECC (2018a)

### 3.7.2 Affected Environment

Sections 3.7.2.1 through 3.7.2.3 describe the power and transmission systems, focusing on those elements that could be affected by the MOs. Section 3.7.2.4 describes the coordination of the two systems. Sections 3.7.2.5 through 3.7.2.10 provide an overview of the Pacific Northwest electric power market in which Bonneville competes, and the factors influencing the rates that Bonneville charges its firm power customers. Section 3.7.2.11 describes the retail electricity market and provides an overview of the regional retail rates paid by end users.

#### *3.7.2.1 Power Generation*

Bonneville sells firm power at wholesale under long-term contracts to 136 power customers within a 300,000-square-mile service area in the Pacific Northwest. The Bonneville service area is geographically located within the boundary of the Western Interconnection power system. The Western Interconnection is one of four major North American power systems and includes power generation and transmission facilities across 14 U.S. states, 2 Canadian provinces, and parts of Mexico (WECC 2018a). Bonneville imports power and exports surplus power (i.e., power not needed to meet Bonneville's firm power commitments) beyond the Pacific Northwest within the Western Interconnection.

Table 3-108 provides a comparison of the power-generating capacity within the Western Interconnection, the Pacific Northwest region, and CRS projects. It is important to recognize that "capacity" is distinct from "energy," and that the MOs have the potential to affect them in different ways. Capacity is defined as the maximum potential output of a generation unit that can be physically produced at any given instant and is commonly expressed in megawatts (MW). Generators are not operated at full capacity at all times, and output can vary according to a variety of factors such as lower demand, market conditions, and variability in fuel sources. In this context, energy is defined as the amount of electricity generated at a project or power plant over a period of time and is expressed in megawatt-hours (MWh) or average megawatts (aMW). An aMW is a unit of energy representing 1 MW of electric power capacity generated continuously over a year. One aMW is equal to 8,760 MWh. Both capacity and energy generation trends are presented in the discussion below.

- **Western Interconnection Resources**: The diverse mix of generation resources, referred to as a "resource mix," in the Western Interconnection constitutes roughly 20 percent of all national power generation, with approximately 40 percent of all national hydropower capacity and 35 percent of all wind and solar capacity. Given the geographic, climatic, and consumer (e.g., urban and rural, residential, commercial, and industrial electricity end users) diversity across the Western Interconnection, demand for and generation of power varies greatly. Coordination across the Western Interconnection allows for planning across this diverse geography to ensure cost-effective and reliable power. Overall, across the Western Interconnection for 2016, there were 94,863 aMW generated, of which hydropower generated roughly 26,000 aMW (WECC 2018a).

- **Pacific Northwest Regional Resources**: The Pacific Northwest regional resources are a component of the Western Interconnection resources. Table 3-108 illustrates the predominance of hydropower capacity (54 percent) in the resource mix of the Pacific Northwest region. Figure 3-159 provides a geographic overview of generating resources in the Pacific Northwest region (NW Council 2018a). There is the potential for non-Federal hydroelectric projects downstream of CRS projects to be affected by the MOs. These projects are highlighted in purple in Figure 3-159, and their generation characteristics are described in Table 3-109. These projects have capacity ranging from 90 to 1,299 MW. For further information, including a list of all projects downstream of the CRS projects, see Section 1.9.3, *Non-Federal Dams and Reservoirs*.

**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** |

Note*:* The estimates across geographic regions are not additive; the Pacific Northwest is geographically within the Western Interconnection. The CRS projects' capacity is for the 14 CRS facilities that would be affected by the MOs, which are a subset of the Bonneville resources.
1/ This column (Bonneville) represents the generation capacity of Bonneville's resources.
2/ This statistic (Bonneville hydropower) represents the total capacity of the FCRPS hydro system, inclusive of the CRS projects.
Source*:* Bonneville (2017b); NW Council (2018a); WECC (2018a)

Total power generation (energy) in the Pacific Northwest fluctuated between 21,821 and 27,407 aMW between 2002 and 2016 (NW Council 2018a). All hydropower (including the FCRPS and non-Federal hydro projects) provided at least 50 percent of the electric power generation every year (Figure 3-160), with wind increasing from less than 1 to 10 percent of the resource mix (113 to 2,687 aMW) over this period.

- **Columbia River System Projects:** The 14 CRS projects that are the subject of the CRSO EIS are a subset of the 31-project FCRPS. Figure 3-159 highlights the CRS projects within the context of Pacific Northwest regional power resources. The projects are some of the largest power-generating resources in the region and constitute 34 percent of total Pacific Northwest regional capacity, with the potential to provide power to 6.6 million homes or roughly 1 million businesses, based on average consumption levels (EIA 2017c; NW Council 2018a).

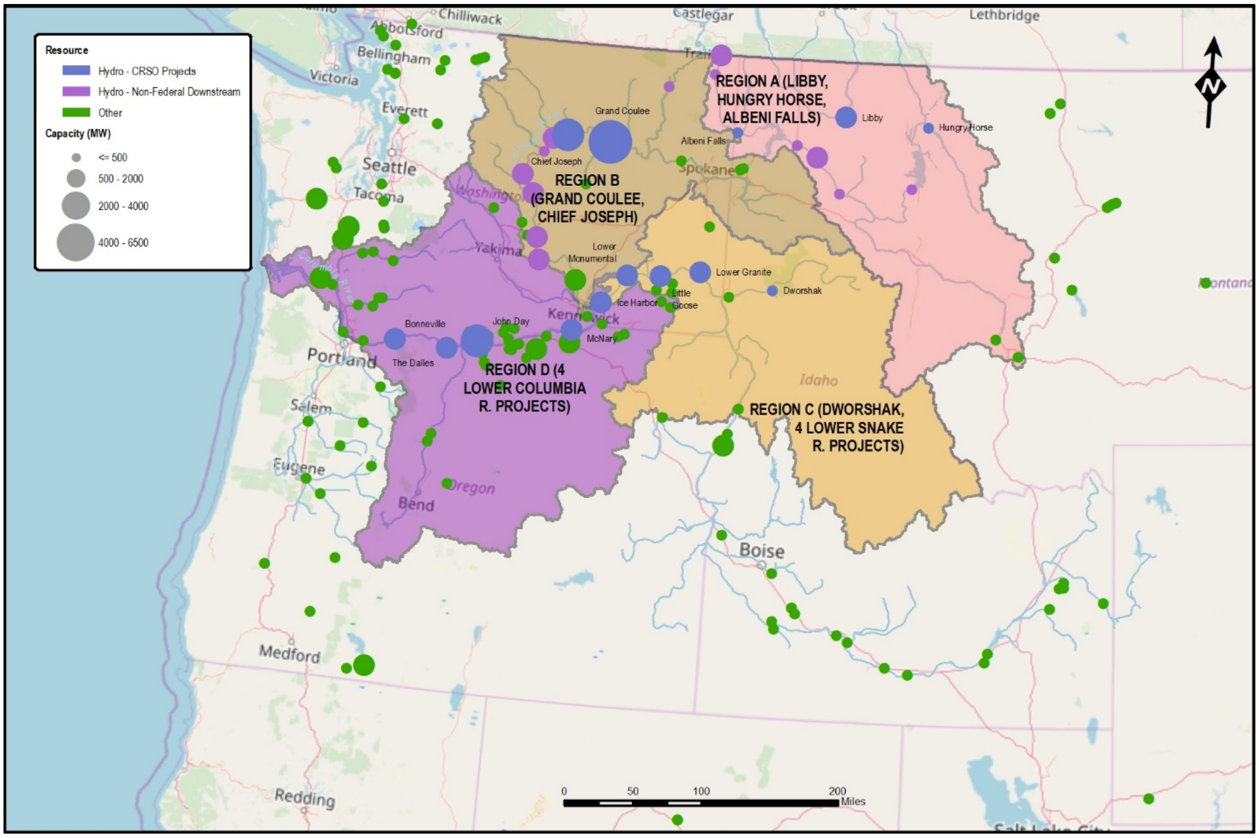


**Figure 3-159. Map of Pacific Northwest Generating Resources in 2018**

Source*:* NW Council (2018a)

**Table 3-109. Non-Federal Projects Downstream of the 14 Columbia River System Projects**

| Project | MW Capacity |
|---|---|
| Seli'š 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 |

Source: NW Council (2018a)

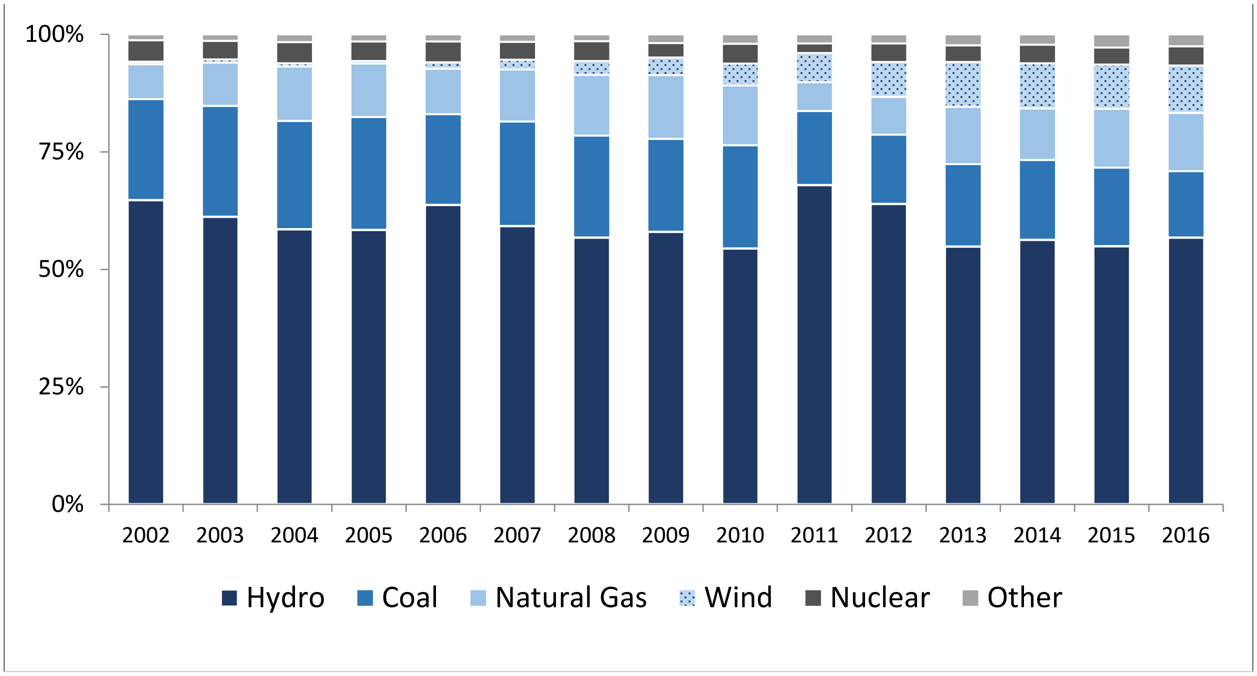


**Figure 3-160. Breakdown of Annual Generation in the Pacific Northwest by Type from 2002 to 2016**

Source: NW Council (2018a)

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 |

| Plant | Units | Capacity (MW) | Average Generation (aMW)[1/] |
|---|---|---|---|
| Hungry Horse | 4 | 428 | 87 |
| Albeni Falls | 3 | 49 | 21 |

1/ 80-year average is identified using the aMW output from the FCRPS system as calculated using the water from the 80 years from 1929 to 2008.

2/ The total number of generators and capacity at Grand Coulee does not include pump generator units, which provide 314 MW of capacity in limited periods of time.

Source: Bonneville (2017b)

These CRS projects operate below full capacity primarily because of the variation in available water, demand for electric supply, reservation of capability to maintain reliability, and constraints on project operation to achieve non-power objectives. An example of the annual variability of flows is illustrated in Figure 3-161, which includes annual water flow at The Dalles. In addition, the availability of water for hydropower is further limited by the need to address other congressionally authorized purposes of the CRS projects.[3] Bonneville also considers the amount of generation available from the CRS projects that can be used to supply "reserves."[4] Consequently, the CRS projects produce, on average, approximately 8,500 aMW (Bonneville 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.

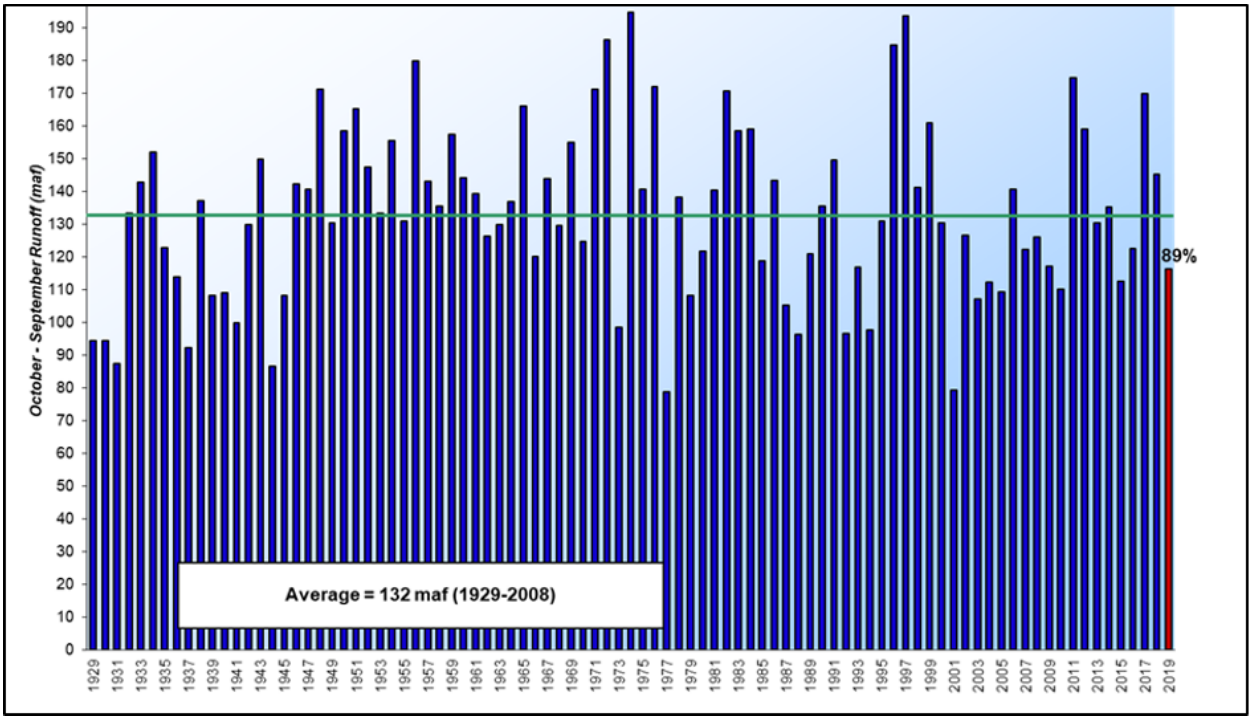


**Figure 3-161. Annual Variability in Runoff at The Dalles in Million Acre-Feet, 1929 to 2019**

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)

#### *3.7.2.2 Power System Flexibility and Reliability*

**SYSTEM RELIABILITY AND LOSS OF LOAD PROBABILITY (LOLP)**

"Power system reliability" refers to the ability of the power supply to meet the demand, and demand for power is typically referred to as "load." The flexibility and capacity of the hydropower system is critical to ensuring power system reliability. Power system reliability is measured and discussed in terms of "loss of load probability" (LOLP) of the region's power supply. LOLP reflects the probability that the region's expected supply of power will not be able to meet the region's demand for electricity.

The NW Council sets the metric (e.g., LOLP) and target for reliability for the Pacific Northwest. Created by the Northwest Power Act in 1980, the NW Council, develops both a regional power plan and Bonneville's Fish and Wildlife Program that together "ensure, with public participation, an affordable and reliable energy system while enhancing fish and wildlife in the Columbia River Basin."[5] The current standard for LOLP set by the NW Council in 2011 is 5 percent, meaning the power supply should have sufficient resources (both generating and energy efficiency) to limit the likelihood of a shortfall to no more than 5 percent during a future year, taking into account, for example, cold snaps in winter and heat waves in summer. 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.

by the total number of simulations studied. For the power supply to be deemed adequate, that fraction must be less than 1/20, equating to an LOLP of 5 percent or less. When the power supply is unable to meet demand, customers could experience blackouts for brief or extended periods of time.

Bonneville actively manages generation from its projects to ensure reliability. Electricity production at the CRS projects and other hydroelectric projects in the interconnected river system is influenced both by the turbine capacity and the amount of water available for generation. The amount of water available at each hydro project varies from year to year, season to season, day to day, and even hour to hour based on variation in flows, as well as operations constraints. The annual snowmelt in the spring leads to higher flows in the late spring and early summer with lower flows in late summer. FRM operations specify that reservoirs must be partially drafted by early spring (water discharged from the reservoirs so some of the high flows from the snowmelt can be stored in the reservoirs). Operations for endangered and other fish species, navigation, irrigation, and other resources also produce constraints on water management. Consequently, the ability for managing the timing of water flow through the Federal projects for power purposes is limited.

When the river flows are high (e.g., the spring freshet) there is more water flowing through the turbines to produce hydropower. This extra generation can exceed the demand for the power from Bonneville's wholesale customers. In these circumstances, Bonneville sells the surplus power into wholesale electricity markets both within and outside the Pacific Northwest. In some years, the forecast made during the winter predicts a large spring runoff, so the storage projects are drafted (reservoir elevation lowered) very deep. However, if the late winter or early spring are unusually dry, Bonneville might not generate as much surplus power and could even be in a position of needing to purchase power on the wholesale market to meet demand and maintain reliability.

Bonneville uses historical streamflow information to predict the pattern of water flow (and range of uncertainty in flows) to forecast how much it can generate during each month of the year. It then compares this forecasted generation to the forecasted demand for power. The storage capability of the CRS is less than the annual average streamflow and is further restricted to address FRM. In addition, further constraints on the use of the CRS for power production have occurred to support non-power objectives, primarily to support juvenile fish migration. While there is some flexibility in the hydrosystem to adjust river flows and generation to meet demand on a short-term basis, the operation of the river is constrained such that river flow dictates how much water is available for generation on a monthly or seasonal scale, and Bonneville uses purchases and sales on the wholesale market to balance the difference between its loads and resources (e.g., the FCRPS, Columbia Generating Station, and other resources acquired on a long-term basis).

**MEETING SYSTEM UNCERTAINTY WITH GENERATION BALANCING RESERVES, DISPATCHABLE RESOURCES, AND RAMPING CAPABILITY**

The demand for power changes constantly. Someone turns on a dishwasher, a business dims its lights in the evening, an electric forklift is plugged in for recharging, and countless other daily activities all lead to constant fluctuations in demand. At the same time, the supply of energy from solar and wind generation can vary with sunshine and wind gusts. To maintain reliability, sufficient generating capacity must be available at all times to meet system variability, balancing the changes in supply and demand. The spare capacity generators hold to respond to system increases or decreases is referred to as "generation balancing reserves." Modifying the operations of hydroelectric or other generation facilities can affect the amount of generation balancing reserves available to the power system, and thus impact Bonneville's ability to maintain power system reliability.

Resources vary in their responsiveness to adjustments in demand. A resource that can adjust quickly to the changing need for generation is referred to as a "dispatchable resource." Hydropower and natural gas-based combustion turbines are considered "dispatchable" because they can adjust production within minutes or seconds. Coal and nuclear in contrast are less dispatchable because they typically require at least 30 minutes to several hours to respond. Solar and wind resources are also very limited in their ability to be dispatchable given the variability to generate. For example, the wind may not blow nor the sun shine when the demand for power is high. As storage technologies (e.g., batteries) continue to develop allowing for storing of excess energy from wind and solar for future use, these renewable resources will become more dispatchable. Currently, however, hydropower and natural gas are the most dispatchable resources in the region and, as such, have a critical role in the ability of the system to meet demand.

Another important attribute of a resource's ability to meet demand is its ramping capability. Ramping capability is similar to dispatchability in that it measures a resource's ability to move on short notice. Ramping capability, typically expressed in terms of a MW range, measures the amount of generation that the resource is able to increase or decrease over a defined time period.

#### *3.7.2.3 Transmission*

The Western Interconnection is a network of roughly 130,000 circuit miles of transmission lines connecting all electric utilities in the West. Generation and load throughout the Western Interconnection must remain in balance continuously in order to ensure the reliable, stable, and secure delivery of power from generation resources to load.

Within the Western Interconnection, electricity typically flows south and west to connect inland generating resources with population centers along the West Coast. Transmission connection points between different geographic areas enables generation and demand to be balanced across a wider footprint (e.g., transmission lines can carry power from the Pacific Northwest south to California and the Southwest during the spring or early summer, when hydropower generation is high and electricity demand is lower in the Pacific Northwest, to areas with higher summer demand).

Bonneville's transmission system connects and moves power generated from Federal and non-Federal dams; nuclear, natural gas, and coal power plants; and solar and wind generation projects to load throughout the Pacific Northwest and beyond. Bonneville owns and operates about 15,000 circuit miles of high-voltage transmission lines and associated substations in the Pacific Northwest. There are over 260 Bonneville substations that collect power, control the flow of power, and deliver electricity to Bonneville customers. Besides the transmission system within the Pacific Northwest, interregional transmission lines also connect Bonneville to Canada, California, the southwestern United States, and eastern Montana.

Electricity moves over Bonneville's transmission system through managed flow paths that consist of one or more high-voltage transmission facilities and transmission lines. As shown in Figure 3-162, Bonneville's transmission system contains multiple "paths," or routes over which power flowing from one point to another is monitored and managed.[6]

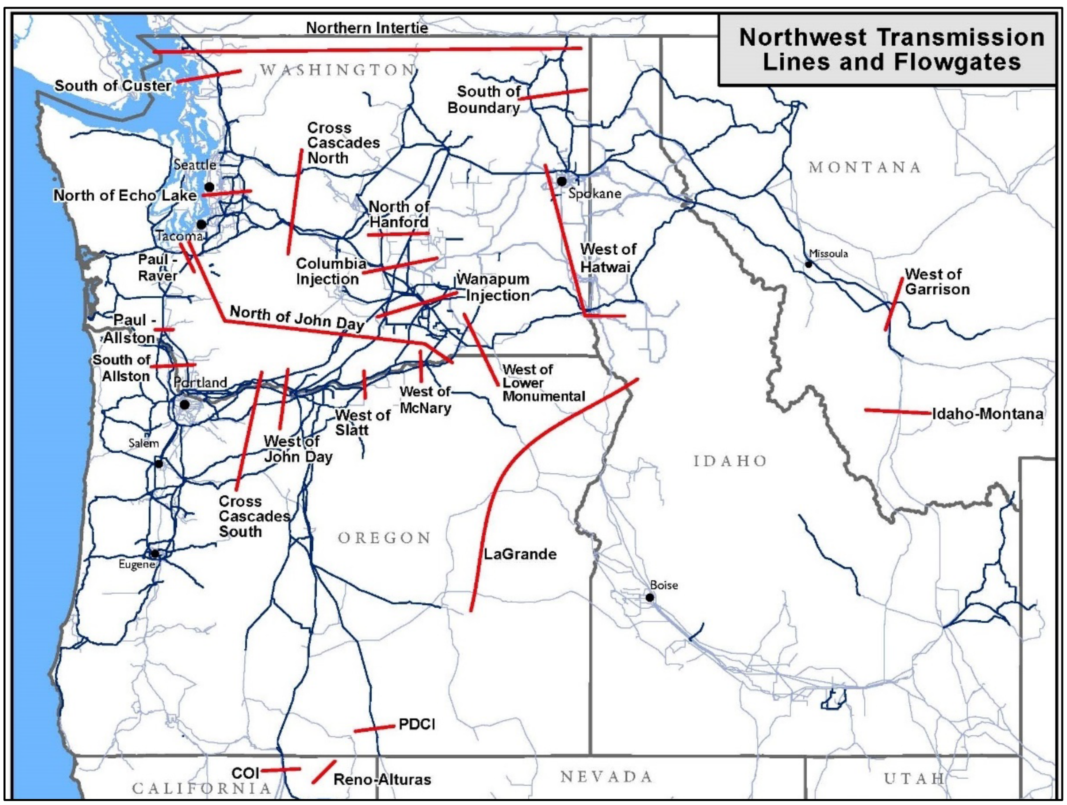


**Figure 3-162. Northwest Transmission Paths**

Note: The blue lines represent actual Bonneville transmission lines, and the red lines denote defined paths, interties, and flowgates (locations where power flows are monitored and analyzed). Transmission lines not operated by Bonneville are in in light gray-blue.

Source: Bonneville (2018a)

[6] See glossary for additional definitions of interties, flowgates, and transmission paths.

**BONNEVILLE TRANSMISSION FLOWS AND LOAD AREAS**

The flow of electricity on the transmission system is a function of the quantity and location of the loads, the amount and location of the generation deployed to meet these loads, and the electrical parameters of the transmission facilities. Flow patterns vary daily throughout the year. Hydropower and fossil fuel generation tends to serve peak loads during the winter when there are high electricity flows running from the east to load centers in western Washington and western Oregon. During the spring, runoff from snowmelt and storage releases from reservoirs such as Grand Coulee and Hungry Horse contribute to relatively elevated flows compared to other times of the year. This runoff results in surplus power that can be exported to other regions, resulting in higher electricity flows north to south on the transmission system. This north-to-south transmission flow path also experiences peak demand during the summer when air conditioning and other uses that influence seasonal peaks place an increased demand on the system.

Although the location of the loads and their seasonality are not likely to shift from year to year, variations in generation across the resource mix can change the flow of power within the Bonneville transmission system. Changes in precipitation patterns and runoff, and changes in the timing and availability of wind and solar power, all have the potential to influence flows across the transmission system. For example, heavy rains or rapid snowmelt along the lower Snake River could result in more water moving through hydropower turbines, increasing generation. This results in increased east-to-west transmission flows in southeast Washington. In addition, recent increases in renewable generation (i.e., wind and solar generation) have increased certain flows such as south-to-north flows for California solar at mid-day. Further, the rapid development of new, large industrial loads—such as server farms-- at times can also introduce changes in the flow of power within the Bonneville transmission system.

**TRANSMISSION RELIABILITY AND CONGESTION**

Impacts to transmission flows due to changes in generation and load can affect transmission system reliability and congestion. Congestion occurs when a transmission path, line, or facility is near or close to its operating limit. Transmission system reliability refers to the ability or inability of the transmission system to deliver energy to serve a load (by contrast, power system reliability, as noted previously, refers to the ability of the power supply to meet the demand, or load).

Under Section 215 of the Federal Power Act, Pub. L. No. 109-58, 119 Stat. 594 (codified at 16 U.S.C. § 824o), FERC has responsibility over the adoption and enforcement of national standards that govern the reliability and security of the bulk power system. The Electric Reliability Organization, currently the North American Electric Reliability Corporation (NERC), has the authority to develop and enforce reliability standards, subject to FERC approval and oversight. In turn, NERC has delegated its authority to Regional Entities with responsibility for developing regional reliability standards and enforcing all standards within the Regional Entity’s area. The Western Electricity Coordinating Council (WECC) is the Regional Entity for the Western Interconnection.

Reliability standards are in place to minimize the frequency and severity of power outages, protecting public health and safety, and avoiding economic disruptions. Reliability standards include requirements to ensure system stability and voltage support (keeping voltage levels within a given range), to provide reserves in case of contingencies, and to provide reserves and automatic generation response to meet ever-changing loads. Flexible generating resources are vital to meeting these reliability standards.

The reliability standards establish various functional entities with responsibility over different aspects of transmission system reliability. Bonneville performs the roles of balancing authority (BA), transmission operator, transmission owner, transmission planner, and planning coordinator.[7] As a BA, Bonneville is responsible for maintaining balance between resources and loads within its balancing authority area (BAA) in real time (minute by minute) by dispatching generating resources within its BAA, thereby ensuring power is provided to meet load ("load service"). Typically generating resources within the BAA are connected to automatic generation control so that the resources can respond instantly to deviations in expected load and generation levels.

The BAs in the Western Interconnection (Figure 3-163) all contribute to supporting the reliability of the interconnection, in part, by exchanging power with other BAs when other BAs are out of balance and cannot address the imbalance with the BA's own resources.

As a transmission operator, Bonneville must operate transmission paths, facilities, and lines within certain operating limits. Changes in supply, demand, pricing, and/or operational availability of specific grid-related assets all influence congestion and methods to relieve congestion (U.S. Department of Energy 2014). Congestion can increase the cost of serving loads by forcing utilities to obtain power from alternative resources that are more costly. If alternative resources are unavailable, congestion could lead to a disruption in service. Increases in transfer capability (the ability to transfer electricity across a transmission path) through appropriate transmission system reinforcements or reducing demand on the system, such as through demand response and energy-efficiency measures, are methods used to relieve congestion on the transmission system and maintain reliability.[8] In addition, as a transmission operator, Bonneville must be prepared to curtail transmission, reconfigure transmission, redispatch generation (decreasing generation to relieve the overloaded transmission path, facility, or line and increasing generation elsewhere on the system to ensure load service), or implement a controlled interruption of electrical service (blackout) to a local area to maintain flows within limits. Otherwise, Bonneville risks equipment damage or, in extreme cases, uncontrolled blackouts.

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[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.


**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)

As a transmission owner, Bonneville has the responsibility to maintain and protect its transmission facilities and lines to ensure that they operate reliably. Finally, as a transmission planner and planning coordinator, Bonneville must plan its transmission system so that it can meet demand without overloading transmission lines and facilities or causing instability.

#### *3.7.2.4 Power and Transmission Coordination*

Real-time management of the CRS projects relies on a high degree of coordination among Bonneville, which operates and maintains the Federal transmission system, and the Corps and Reclamation, which operate the CRS projects. Bonneville is responsible for ensuring it has sufficient resources available to meet its contractual power obligations. In the event the Administrator cannot be assured on a planning basis of acquiring sufficient resources to meet Bonneville's power supply obligations, the Administrator may issue a notice of insufficiency to all firm power customers. Such a notice allows Bonneville to restrict and physically allocate the remaining power among the firm power customers. Given an insufficiency of resources, there would likely be significant impacts to transmission system operations. In power emergency situations or in the case of an imminent power emergency, Bonneville, in coordination with the Corps and Reclamation, can implement a variety of measures to prevent disruption in service, such as temporarily spilling less water so that more water is run through the turbines to produce power.

In the case of transmission system congestion, Bonneville transmission operators can dispatch Federal generation to address the power flows that are contributing to the congestion or reliability issues. For example, in 2016, due to transmission congestion leading into the Tri-Cities area in southeastern Washington, high loads, and spill at Ice Harbor Dam, a transmission system emergency was declared in order to interrupt spill and increase generation at Ice Harbor Dam. This action prevented overloading the congested transmission facilities in the area and ensured load service. Absent the ability to increase generation under such circumstances, equipment damage and/or the loss of load (i.e., blackouts) could result.

#### *3.7.2.5 Bonneville Power and Transmission Customers*

**FIRM POWER CUSTOMERS**

In its role as the designated marketing agent for the power produced by the FCRPS, Bonneville is statutorily required to provide preference and priority in selling power to public bodies and cooperatives, including tribal utilities ("preference customers").[9] Bonneville also sells power to IOUs, Federal agencies, and DSIs. All of these customers purchase "firm" power from Bonneville, which is power that is guaranteed to be continuously available, except for reasons of force majeure. These entities are referred to as "firm power customers" when purchasing power from Bonneville pursuant to Sections 5(b), (c), and (d) of the Northwest Power Act. 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).

1 DSI customer (Bonneville 2018a).[10] None of the region's IOUs are currently buying firm power under long-term contracts. [11]

Figure 3-164 presents a map of the service areas of Bonneville's utility customers.

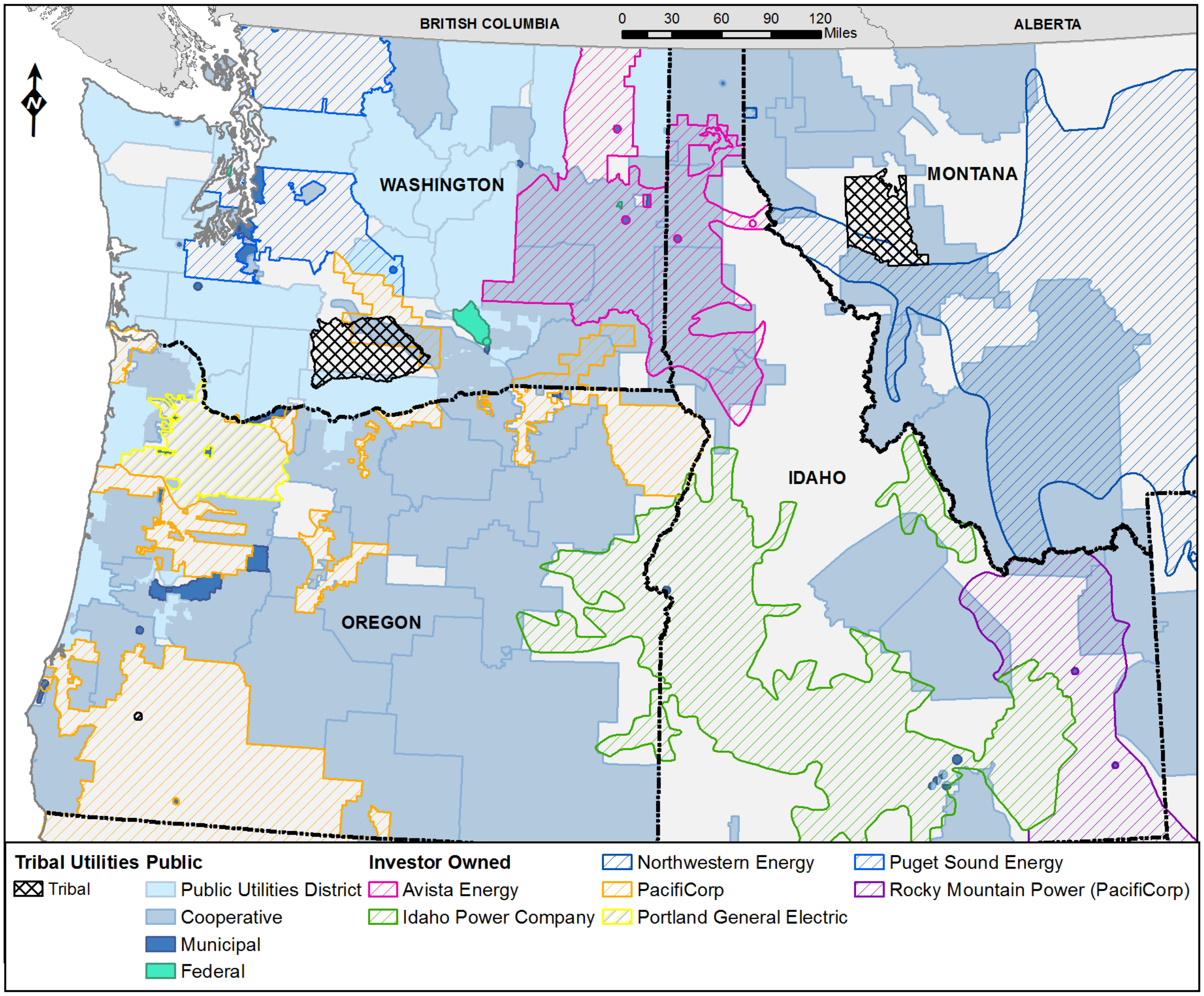


**Figure 3-164. Bonneville Utility Customers in the Pacific Northwest**
Source: Bonneville (2018a)

[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.

**SURPLUS POWER SALES**

Power produced by the Federal Base System,[12] which includes the FCRPS, that is surplus to Bonneville's firm power obligations can be sold as "surplus." Surplus power includes uncommitted firm power that is produced under critical water conditions and non-firm, or secondary power, which is produced when water conditions are above critical levels (*i.e.,* average water conditions). Bonneville markets this surplus power to a mix of public, private, and extra-regional customers throughout the Western Interconnection through wholesale power markets.

**COMPETITIVE PRESSURE ON BONNEVILLE'S POWER RATES**

Bonneville's current firm power sales contracts with preference customers expire in 2028. After 2028, these customers will have a choice to either purchase from Bonneville or from other power suppliers. A key factor influencing the power supplier decision will be Bonneville's expected firm power rates compared to other choices in the wholesale power market (i.e., the "spot market"). Over the past decade, the average spot market price for power has steadily declined due to the abundance of low-cost natural gas and the large-scale development of variable renewable energy resources, such as wind and solar. During this time, Bonneville's power rates have increased due to cost increases in several programs related to the operation of the Columbia Generating Station, investments associated with Federal infrastructure, Endangered Species Act requirements, implementation of the Columbia Basin Fish Accords, and the effect from decreased secondary sales revenue due to lower market prices. It is important to note the spot market price is not directly comparable to Bonneville's rates because Bonneville provides a high-quality power product that is backed by Federal Base System resources, which includes the FCRPS and the Columbia Generating Station. Bonneville's firm power customers, thus, receive a power product that provides a reliable and stable supply of power at predictable prices set by Bonneville's statutory process. Spot market purchases, in contrast, are volatile, with supply not assured and pricing subject to market spikes.

Preference customers have, nonetheless, pointed to the sustained divergence in spot market prices and Bonneville's rates as evidence of the diminishing long-term affordability of Federal power. Almost 80 cents of every dollar of power revenue Bonneville receives comes from sales of firm power to preference customers; thus, maintaining sales to these customers is vital in order for Bonneville to continue to recover its costs and provide affordable Federal power to Pacific Northwest residents and businesses.

Bonneville has taken steps to manage its costs so that Federal power remains competitive and affordable for the long term. As part of those steps, Bonneville has developed a 2018–2023 Strategic Plan that includes a goal of providing competitive power products and services at low, 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).

Bonneville was able to adopt a flat base power rate, i.e., no rate increase, for fiscal years 2020-21. While this was a first step, Bonneville will need to maintain its new rate trajectory over the next eight years and into the term of its new contracts to provide adequate, efficient, economical, and reliable power supply in 2028. For this reason, sustaining Bonneville's competitiveness remains a core focus of the agency. The risks associated with achieving this goal in light of the MOs in this EIS are described in Section 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*.

**TRANSMISSION CUSTOMERS**

Bonneville provides transmission services and associated ancillary services to more than 300 customers, including PUDs, DSIs, municipalities, cooperative utilities, IOUs, Federal agencies, a port district, tribal utilities, independent power producers, and power marketers. Bonneville's transmission customers extend largely throughout the Western Interconnection, the boundaries of which are depicted in Figure 3-157. Bonneville also has "generator interconnection" customers that have connected non-Federal generating facilities to Bonneville's transmission system.

#### *3.7.2.6 Power and Transmission Rate Case*

Establishing Bonneville's wholesale power and transmission rates is a complex public process set forth in the Northwest Power Act. The process is referred to as a "rate case" and is subject to the rate-making procedures in Section 7(i) of the Northwest Power Act.[13] Bonneville is obligated to periodically review and revise rates to ensure cost recovery, but not less frequently than every 5 years. Currently Bonneville conducts a rate case every 2 years to establish power and transmission rates for the next 2-year rate period. The current rates, referred to as BP-20 rates, were developed as part of the rate case undertaken in 2019. The rates for Bonneville's power sales are separate from the rates for transmission services.

#### *3.7.2.7 Power Rate Determination*

Power rates are calculated based on an iterative process that involves three general components: (1) a forecast of expected supply from federally owned or acquired resources; (2) a forecast of firm (and non-firm) power sales commitments (referred to as "forecasted load"); and (3) a forecast of costs to be recovered from the forecasted load over the rate period ("revenue requirement"). The components of the rates analysis are described briefly below.

**POWER SUPPLY**

**Firm Power**

Bonneville forecasts the expected firm power from the FCRPS by modelling expected generation under critical water conditions. The historic water year of 1937 (October 1936 to September 1937) is referred to as the "critical water year." Critical water year or critical water

[13] 16 U.S.C. § 839e(i) (2018).

conditions represent the historic water conditions under which the capability of the hydro system produces the least amount of dependable generation while considering power and non-power operating constraints. Modelling expected generation under critical conditions includes accounting for the following power and non-power operations: FRM constraints; the Columbia River Treaty with Canada; the Endangered Species Act Biological Opinion requirements; meeting reclamation/irrigation and other water supply requirements; and transmission system support. The power generated while meeting these operational needs under critical water conditions is available to supply as firm power.

**Surplus Power**

Surplus power refers to energy or capacity that remains after Bonneville's total firm power obligations have been met. Surplus power generally comes in two forms. "Surplus firm power" is power produced by the Federal dams based on modeling under critical water conditions; surplus firm power includes power from Bonneville's other, non-hydropower system resources. Non-firm or "secondary surplus power" is power produced by the Federal dams based on modeling of better than water conditions; secondary surplus power only includes the increase in power generation capability from hydropower resources. Average water conditions refers to the amount of power the FCRPS would likely produce assuming the 80-year average generation (based on historical water flow from 1929 to 2008).

Table 3-111 compares firm energy and average energy generation for the CRS projects. The difference between the amount of firm power produced under critical water conditions ("Firm Energy" column) and the amount of energy produced under 80-year average generation ("80-Year Average Generation" column) approximates the average secondary surplus energy ("Average Secondary Surplus Energy" column). Secondary surplus power is sold on the wholesale markets or through other contractual arrangements. Any revenue from the sale of surplus power serves to reduce the rates that Bonneville charges to its firm power customers.

**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** |

Note: One aMW is equal to 8,760 MWh.
Source: Bonneville (2017b)

### FIRM LOAD FORECAST

Load is the measure of demand for electric power by end users. End user consumption is referred to as "retail load." Retail load fluctuates on a daily and seasonal basis but is fairly predictable over the course of a year, resulting in predictable patterns or "shapes" that reflect the size and timing of demand. Bonneville and regional utilities reference these load shapes to forecast demand for electricity for planning purposes.

Bonneville's preference customer load forecast in the BP-20 rate case was 6,714 aMW. Bonneville forecasts the total retail load of each of its utility customers including each utility's "peak load," the maximum demand for electricity during a time period (EIA 2017d; EIA 2018a). The "net requirement for power" that Bonneville is obligated to supply relies on forecasting each utility's load, peak loads, and the projected output of the utility's own resources (if any). The total load across the region has remained relatively constant over the past decade with small increases in the peak loads, except in areas such as The Dalles, Boardman, and Central Oregon where there have been larger amounts of industrial load growth associated with data centers and other development.

Peaks can be examined for an hour, a single day, weekly, or monthly. Bonneville also considers "sustained peaking capacity" (6 peak hours per weekday for a month, or super peak capacity) of the FCRPS to determine how much power could be delivered should an extended peak occur such as a cold snap or heat wave. Seasonal patterns of power use across Bonneville's transmission system reflect winter peaks (highest loads occur in November through February). Most areas west of the Cascade Range are winter peaking, with summer (June through September) peaks in just a few of these areas (FERC 2016; NW Council 2016; EIA 2017d).

### POWER REVENUE REQUIREMENT

Bonneville is a self-funded, not-for-profit government entity that is required by statute to ensure that the rates it charges are set to recover its costs consistent with sound business principles. Bonneville recovers its costs by establishing a "revenue requirement," which is a list of projected costs for a rate period that must be paid by revenues generated from rates. The revenue requirement for power rates is comprised of three major categories:

- Program costs (O&M, employee costs, fish & wildlife, conservation)
- Debt payments including principal and interest
- Costs calculated through the rate setting process (Residential Exchange Program, power purchases, cost of transmission, and rate discounts).

The projected program costs are discussed through a public process, the Integrated Program Review, prior to the initiation of the rate setting process.

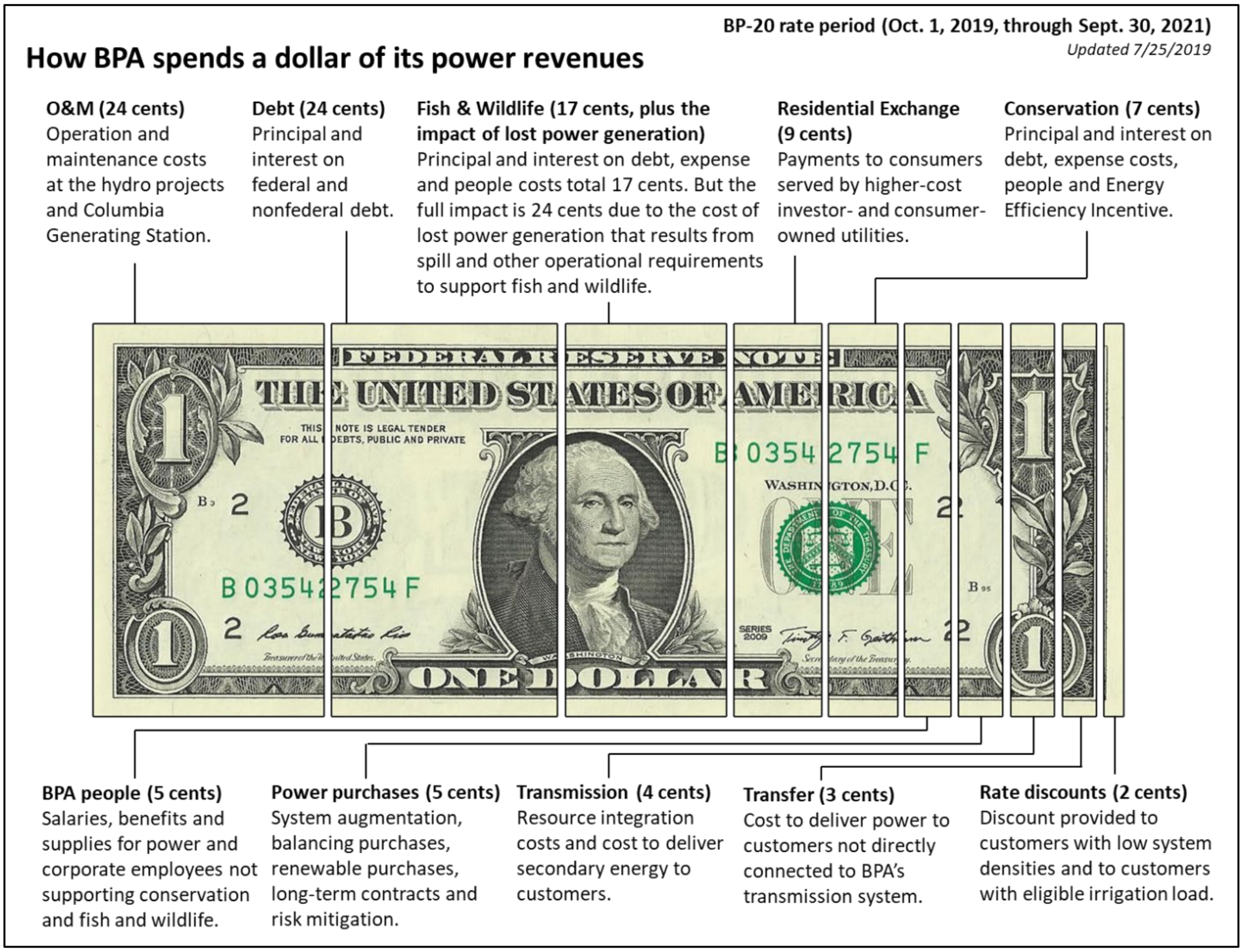


**Figure 3-165. BPA Power Revenues**

The generation costs for the CRS projects (per MWh) vary considerably among the larger facilities, with costs for John Day at $4.70 per MWh, and Bonneville at $17 per MWh (Bonneville, Corps, and Reclamation 2016). Costs vary due to a variety of factors including operations and maintenance, the age of generators and associated depreciation, and fish management. Table 3-112 shows the total generation for 2015 and the cost per project and per MWh.

**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** |

Note: One aMW is equal to 8,760 MWh.
Source: Bonneville, Corps, and Reclamation (2016)

A variety of cost factors other than operations and maintenance of FCRPS generating resources and repaying the U.S. Treasury for debt related to these projects are included in the power revenue requirement and directly affect power rates. These include, but are not limited to the following:

- **Residential Exchange Program:** The Northwest Power Act requires Bonneville to acquire power from utilities with high cost resources and sell them lower cost Federal power. This is known as the Residential Exchange Program (REP). Historically under this program, actual power is not exchanged but Bonneville pays the participating utility the difference between the cost of their power and the cost of Bonneville's power. The REP was created to mitigate wholesale rate disparity between Bonneville's preference customers and regional IOUs.
- **Bonneville Energy Efficiency and Demand Response Programs:** The NW Council's Power Plan includes energy-efficiency targets for Bonneville and the Pacific Northwest utilities that are based in programs designed to reduce end user loads through conservation (e.g., installing appliances or light fixtures that require less electricity). Bonneville is also testing a variety of demand-response pilot programs that would help manage electricity consumption.
- **Bonneville Fish and Wildlife Program and Lower Snake River Compensation Plan:** Bonneville's Fish and Wildlife Program funds hundreds of projects each year to mitigate the impacts of the development and operation of the Federal hydropower system on fish and wildlife. Bonneville began this program to fulfill mandates established by Congress in the Northwest Power Act to protect, mitigate, and enhance fish and wildlife affected by the development and operation of the FCRPS. Each year, Bonneville funds projects with many local, state, tribal, and Federal entities to implement offsite mitigation actions listed in various Biological Opinions for ESA-listed species. Offsite protection and mitigation actions typically address impacts to fish and wildlife not caused directly by the CRS, but they are actions that can improve the overall conditions for fish to help address uncertainty related to any residual adverse effects of CRS management. For example, Bonneville's F&W

Program funding improves habitat in the mainstem as well as tributaries and the estuary, builds hatcheries and boosts hatchery fish production, evaluates the success of these efforts, and improves scientific knowledge through research. This work is implemented through annual contracts, many of which are associated with multi-year agreements like the Columbia River Basin Fish Accords, the Accord extensions, or wildlife settlements. To make the most of available funds, investments in fish and wildlife mitigation are prioritized based on biological and cost effectiveness and their connection to mitigating for impacts to the CRS. Funding decisions for the Bonneville Fish and Wildlife Program are not being made as a part of the CRSO EIS process. However, a range of potential F&W Program costs are included to inform the potential power revenue requirements for each alternative in this chapter and to inform the broader cost analysis for each alternative in Section 3.18. Future budget decisions would be made with regional input through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements.

Bonneville also directly funds the annual operations and maintenance of the Lower Snake River Compensation Plan (LSRCP) facilities. 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 projects. A major component of the authorized plan was the design and construction of fish hatcheries and satellite facilities. The LSRCP is administered through the U.S. Fish and Wildlife Service (USFWS). The LSRCP hatcheries and satellite facilities produce and release more than 19 million salmon, steelhead, and resident rainbow trout annually as part of the program's mitigation responsibility. The 25 LSRCP hatcheries and satellite facilities are operated by Idaho Fish and Game (IDFG), Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), USFWS, the Nez Perce Tribe (NPT), Confederated Tribes of the Umatilla River (CTUIR), and Shoshone-Bannock Tribes (SBT). LSRCP would be continued, consistent with the No Action Alternative, under all of the MOs except for MO3.

- **Low Density Discounts:** The Northwest Power Act includes provisions for a low-density discount to compensate customers with unusually high distribution costs because of geographic location.
- **Irrigation Rate Discounts:** Historically, Bonneville has provided discounts to customers who serve rural agricultural loads. Irrigation rate discounts support the mission of Bonneville and the FCRPS to provide economic power to all customers across the region.[14]

The environmental consequences analysis relies on the expense forecast developed as part of the BP-20 rate case. This forecast considers capital expenses, Bonneville Fish and Wildlife Program costs, and various structural and operational costs, and how these vary under each MO.

[14] These discounts are not to be confused with Reclamation Project Use Power for irrigation delivery for authorized loads.

**POWER RATE CALCULATION**

Bonneville currently uses a tiered rate methodology (TRM), adopted in 2008, to set the priority firm (PF) power rates for power sold under the Regional Dialogues power sales contracts. As a key feature of the TRM, prior to the rate case, Bonneville evaluates the rate period high water mark (RHWM), which is the maximum planned amount of firm power supplied by the FCRPS and acquired resources that can be sold at Tier 1 rates. This type of power is called Tier 1 System Capability and is sold at Tier 1 rates. (For a sense of scale, Tier 1 rates average around $36 per MWh under the No Action Alternative.) The RHWM is based on forecasted FCRPS generation under 1937 critical water conditions and expected customer load. The RHWM is established just prior to each rate case and is set for the rate period. After calculating the costs and credits included in the revenue requirement described above, the expected revenues from the forecast of sales of secondary surplus energy on the wholesale market are allocated as a reduction in the revenue requirement. This net cost divided by the forecast of firm power necessary to meet expected demand is the Tier 1 rate for a Bonneville preference customer. If a preference customer's load exceeds its RHWM, the utility must choose to either purchase the power in excess of its RHWM from Bonneville at the "Tier 2" rate, supply the load with non-Federal power, or a combination of the two. Bonneville's Tier 2 rates recover the cost of incremental power that Bonneville purchases to serve customer-specific load growth.

#### *3.7.2.8 Bonneville Wholesale Power Rates*

The level of Bonneville's wholesale PF rate has ranged from below $20 per MWh in the 1980s to the BP-20 average rate of $35.59 per MWh, without accounting for inflation (Bonneville 2018a). In inflation-adjusted dollars, Bonneville rates have varied over time, but on average have remained within a relatively limited range (the "real 2018 dollars" in Figure 3-166 are adjusted for inflation).

Established in 2019, BP-20 rates are as follows:

- Average Tier 1 PF rate is $35.62 per MWh.
- Average Tier 2 PF rate is $31.76 per MWh.

Note that these are rates for Bonneville's sale of wholesale power to utilities, with Regional Dialogues power contracts. The rates these utilities charge their customers (i.e., retail rates to end users) are discussed below.

Bonneville also sells surplus energy on regional wholesale electricity spot markets. From such sales Bonneville receives revenue, which is reflected as a credit (i.e., secondary energy credit) in Bonneville's rate making process to lower the PF rate. When setting rates, Bonneville forecasts its expected secondary energy credit for selling surplus power over a given rate period. This forecast does not guarantee that Bonneville will receive the estimated credit as actual prices for, and the supply of, surplus energy can fluctuate daily, if not hourly.

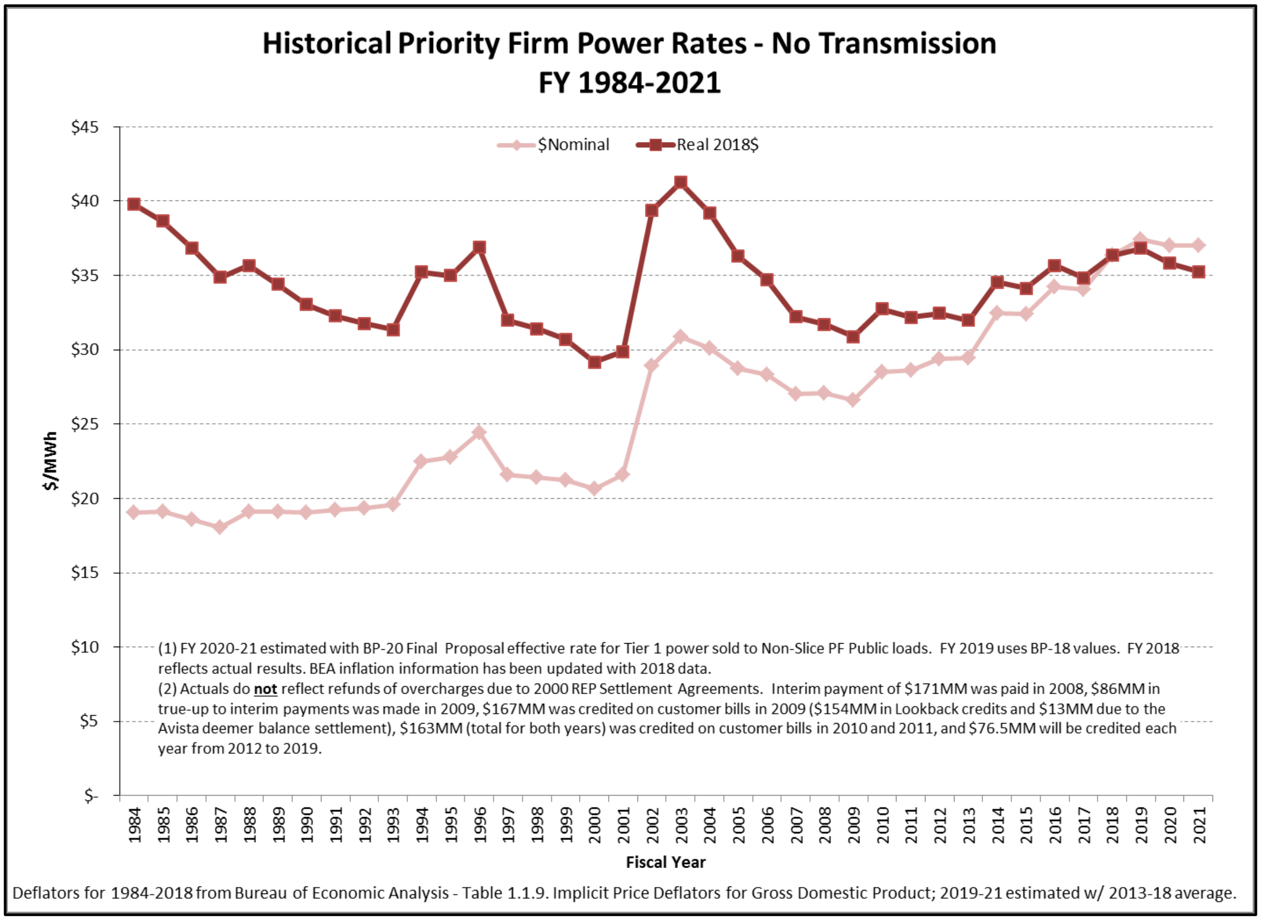


**Figure 3-166. Historical Bonneville Power Rates**

Note: The two lines represent Bonneville power rates in nominal dollars (not accounting for inflation) and in real 2018 dollars (adjusted for inflation).

Source: Bonneville (2018c)

#### *3.7.2.9 Transmission Rate Determination*

Bonneville's rates for transmission services are separate from those for the sale of power. Like power rates, however, transmission rates are established every 2 years in a rate case and are based on a transmission revenue requirement that includes capital-related costs and operating expenses determined in the Integrated Program Review. (Bonneville 2018c).

**SEGMENTATION OF THE TRANSMISSION SYSTEM**

"Segments" are a vital component of the Bonneville transmission ratemaking process. The ratemaking process involves a segmentation study that analyzes and classifies transmission facility investment (such as transmission lines and substation equipment) based on the function the facilities serve or the service the facilities are used to provide. The segments include:

- **Network:** Core of the transmission system, which supports transmission of power from Federal and non-Federal generation sources or interties.

- **Southern Intertie:** Interregional transmission connection to California.
- **Eastern Intertie:** Interregional transmission connection to Montana.
- **Generation Integration:** Connection of Federal power generation to the transmission system.
- **Ancillary Services:** Control and communication equipment to provide transmission system reliability services.
- **Utility Delivery:** Low-voltage facilities associated with supplying power directly to utility distribution systems.
- **Direct Service Industry Delivery:** Equipment used to step down transmission voltages to industrial voltages for DSI customers.

Bonneville offers various forms of transmission service on the Network and Intertie segments of the transmission system. On the Network segment, Bonneville offers network integration (NT) and point-to-point (PTP) transmission service, along with the associated ancillary services.[15] In addition, Bonneville offers PTP transmission service (and ancillary services) on the Intertie segments. For PTP transmission service, Bonneville offers firm service (service that is reserved in advance and is the last service interrupted in the event of congestion on the system) on a long-term (longer than 12 months) or short-term (less than 12 months) basis. Bonneville also offers short-term non-firm service (scheduled and paid for on an as-available basis and subject to interruption before firm service if there is congestion).

### TRANSMISSION REVENUE REQUIREMENT AND RATE CALCULATION

Bonneville sells transmission service on a wholesale basis. Through the transmission rate development process, rates are derived for the various services on the different segments of the transmission system. To derive the rates, each segment's share of the total transmission revenue requirement is identified based on the results of the segmentation study. In addition, transmission sales for the Network and the Intertie segments are forecast, along with revenues from sources other than sales of transmission service at general transmission rates. Revenue from other sources includes items such as fixed-price contracts, contracts that specify the rates for services, use-of-facilities contracts, and fixed-price fees. These revenues (referred to as "revenue credits") serve to offset a portion of the total revenue requirement for the appropriate segment(s). Based on the segmented revenue requirement and forecasted sales, transmission rates are calculated for each type of service that Bonneville offers on each 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

#### *3.7.2.10 Bonneville Transmission Rates*

For the BP-20 rate period (fiscal years 2020 and 2021), the rates for transmission service on the Network segment are:

- $1.771 per kilowatt (kW) per month for NT service.
- $1.533 per kW per month for long-term firm PTP service, and between $0.050 and $0.070 per kW per day for short-term service depending on the length of service, with hourly service at 4.41 mills per kilowatt hour (kWh)

The rate for long-term firm PTP service on the Southern Intertie is $1.084 per kW per month. Rates for short-term Southern Intertie service are between $0.036 and $0.050 per kW per day, with hourly service at 9.98 mills per kWh. The rates for all of Bonneville's other transmission services and the various ancillary services can be found in the BP-20 transmission rate schedules.[16] Figure 3-167 depicts the rate for long-term transmission service on the Network segment from 1984 to present. The figure describes the trend with (real 2015 dollars) and without (nominal dollars) adjusting for inflation. A variety of factors affect the historical trend for transmission rates including the age of infrastructure, rate design, and rate case settlements (where rates are held to a certain level, based on settlement agreement with customers).

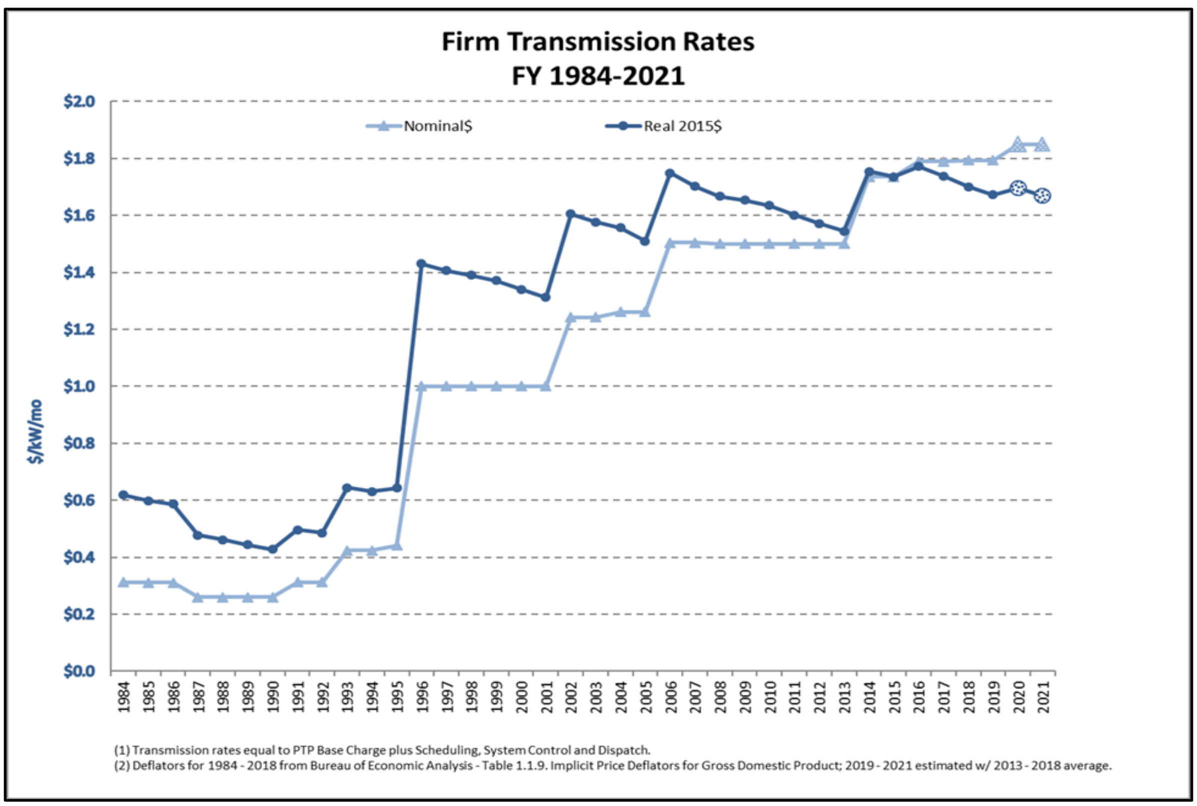


**Figure 3-167. Historical Firm Network Transmission Rates**

Note*:* The two lines represent Bonneville transmission rates in nominal dollars (not accounting for inflation) and in 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.

#### *3.7.2.11 Regional Retail Electricity Rates*

Retail electricity rates are the rates charged to individual end users, including residential, commercial, and industrial consumers. Retail rates vary by the type of utility and service. Retail rates typically are a "bundled" rate that reflect the cost of wholesale power, including the cost of the wholesale transmission of that power from the generator to the utility's system, combined with the cost of the distribution system used to deliver the power to end users.

Retail electricity rates in the Pacific Northwest have historically been among the lowest in the country (EIA 2017a).[17] In 2016, across Pacific Northwest utilities, the average residential rate was 10 cents per kilowatt hour (kWh) (EIA 2017c). On average, the electricity cost per kWh in the Pacific Northwest is 2 cents lower (22 percent lower) than the national average. As of 2016, Washington had the lowest overall electricity rate in the nation. On average, commercial end users across the Pacific Northwest pay between 8.57 and 10.12 cents per kWh compared to a national average of 10.66 cents per kWh. Similarly, industrial end users in the region pay between 4.6 and 6.66 cents per kWh, below the national average of 6.88 cents per kWh.[18]

In the Pacific Northwest, average residential electricity bills range from $88.95 to $96.71 per month, which is roughly $20 lower (21 percent) than the national average of $112.59 (EIA 2017c).[19] As a percentage of income, residents in the Pacific Northwest spend 2.1 percent of median income on electricity. However, there are several locations in the Pacific Northwest where expenditures on electricity are as high as 5.1 percent of median household income, making these areas and their associated low-income populations more vulnerable to fluctuating electricity prices. An analysis of regional residential electricity rates in 2016 by the NW Council found that rural utility customers consume and spend more on electricity than urban customers. The higher consumption in rural areas results from widespread electric heating, low electricity prices, and a generally lower adoption rate of energy efficiency measures. With higher average spending and lower average incomes, the percentage of rural income spent on electricity is considerably higher.

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[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.

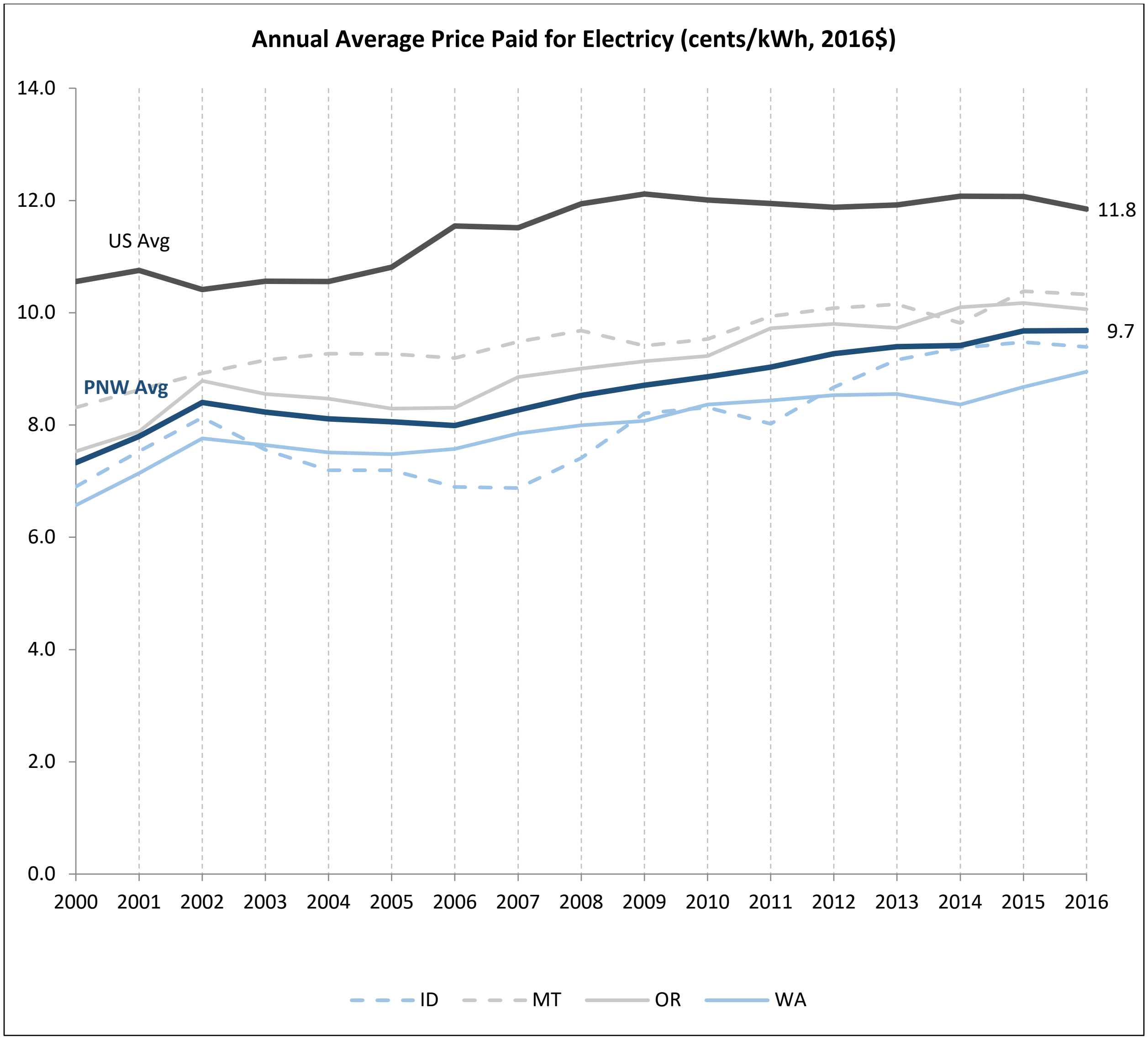


**Figure 3-168. Annual Average Retail Price Paid for Residential Electricity by State and the National Average, 2000 to 2016**

Note: Because of the geographic breakdown of the data source, the Pacific Northwest average includes all of Idaho, Oregon, Washington, and Montana.

Source: EIA (2017c)

Figure 3-169, Figure 3-170, Figure 3-171, and Figure 3-172 illustrate electricity rates for the residential sector, median household income levels by county, and average consumption by utility area.[20] Expenditures are up to 5 percent of income in some of the more rural counties 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.

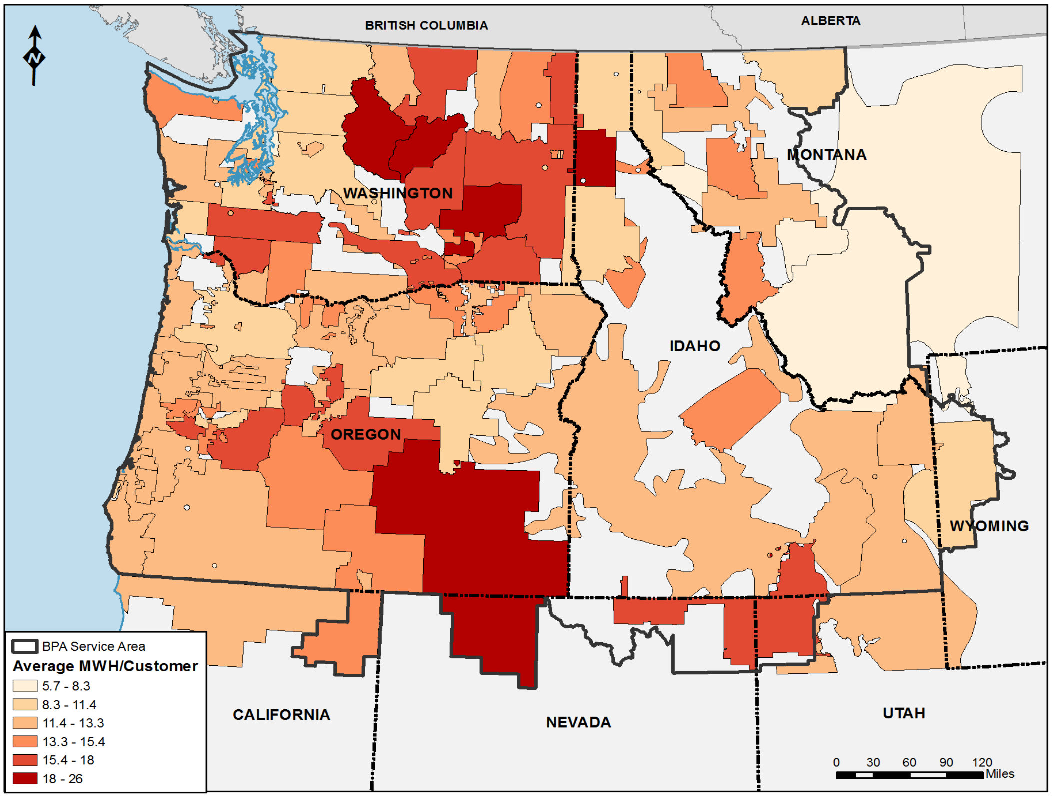


**Figure 3-169. Residential Electricity Consumption**

Note: The boundary of the region shown is the Bonneville service area.

Source: EIA (2017c), Bonneville (2018b)

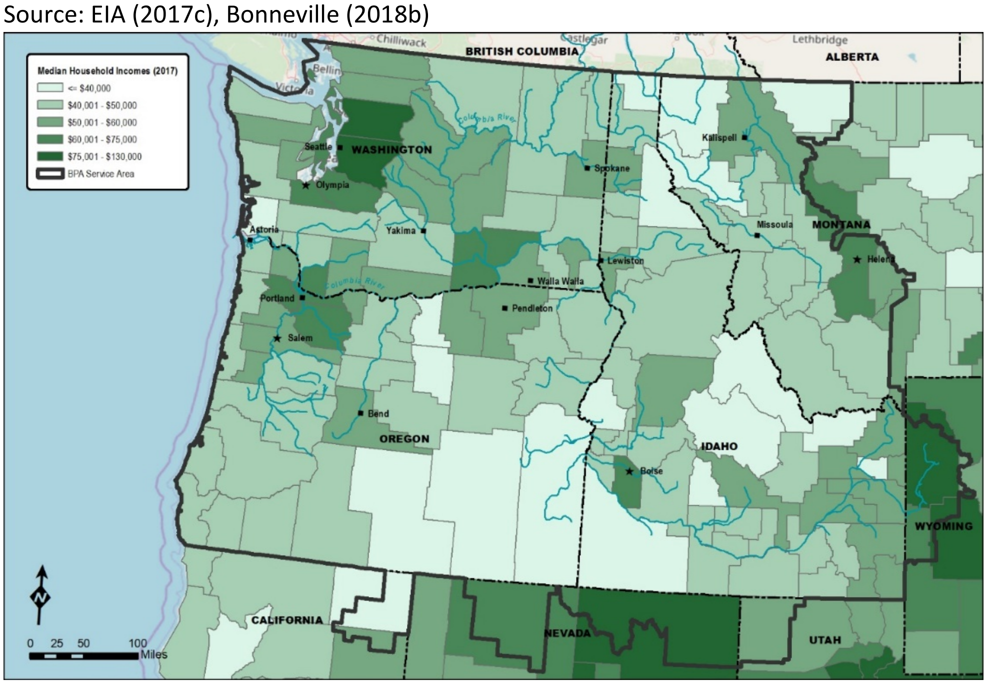


**Figure 3-170. Median Household Income**

Note: The boundary of the region shown is the Bonneville service area.

Source: Census (2017a)

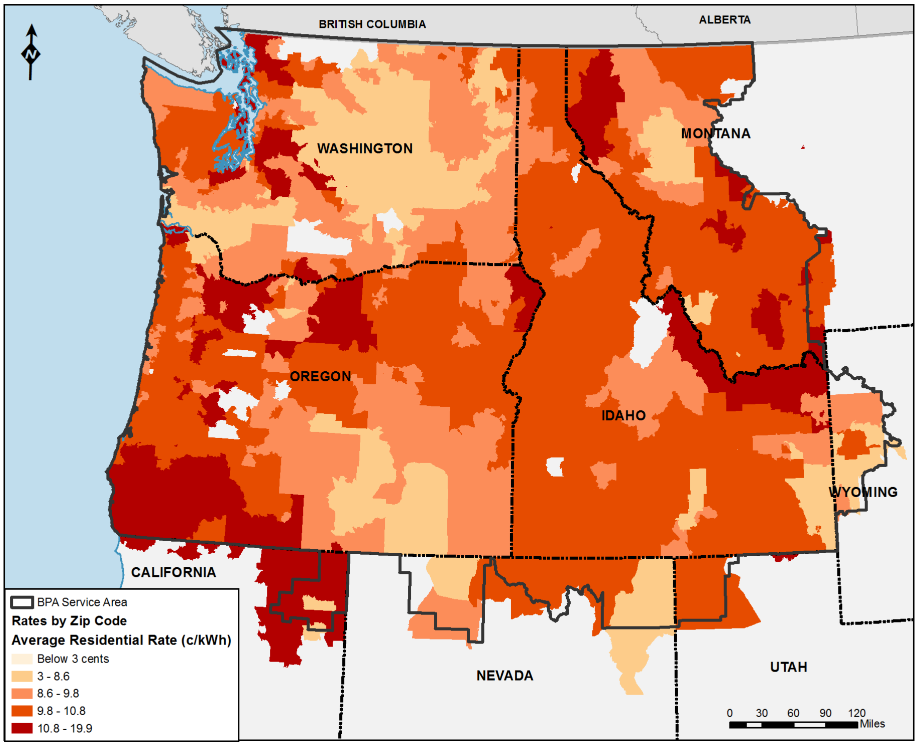


**Figure 3-171. Residential Electricity Rates**

Note: The boundary of the region shown is the Bonneville service area.

Source: U.S. Department of Energy (DOE) and National Renewable Energy Laboratory (NREL) (2018)

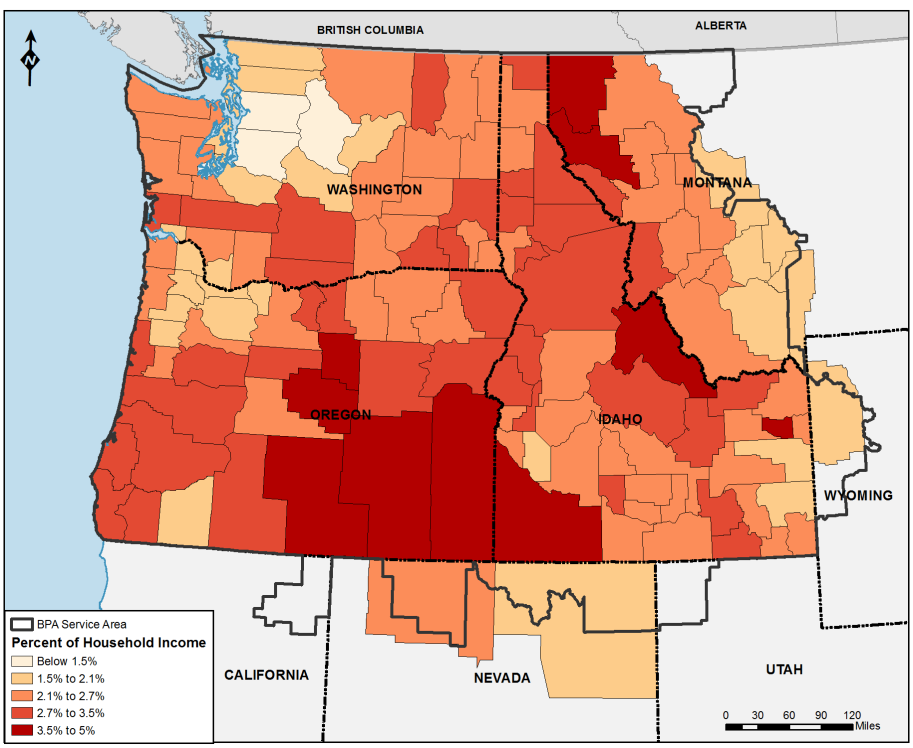


**Figure 3-172. Electricity Expenditures per Household**

Note: The boundary of the region shown is the Bonneville service area.

Source: Bonneville (2018b), Census (2018); EIA (2017c)

### 3.7.3 Environmental Consequences

This section evaluates effects of the No Action Alternative and the MOs on power generation, power and transmission system reliability, power flows across the transmission system, electricity rate pressures, and the cost of living and doing business in the Pacific Northwest. A summary comparing the effects of the No Action Alternative and the MOs is included in Section 1.3 of Appendix H, *Power and Transmission*. Chapter 7, *Preferred Alternative*, describes the power generation and transmission effects associated with the Preferred Alternative.

#### *3.7.3.1 Base Case Methodology and Cost Sensitivities Analysis*[21]

The future of power generation and transmission across the Pacific Northwest is subject to uncertainty, even under the No Action Alternative, due to evolving policy (e.g., emissions reductions targets), environmental factors (e.g., climate change) and technological growth. In order to evaluate the potential effects of the MOs against the No Action Alternative, the power generation and transmission analysis requires a common set of assumptions regarding these factors. These common assumptions, as identified throughout the methodology and results discussion, form the "base case" for the analysis. With respect to key uncertainties, the analysis employs alternative scenarios to produce a reasonable range of potential effects of the MOs, as described in the Base Case Methodology section, below.

Not all key uncertainties influencing the analysis are accounted for in the base case, therefore the analysis provides additional sensitivity analysis and other regional cost pressure describing the sensitivity of the power and transmission rate pressure effects to alternative assumptions. For example, a key factor influencing the overall power generation and transmission effects analysis that is not reflected in the base case analysis is the potential extent of future coal plant retirements. The base case assumptions regarding future coal capacity developed for this analysis in 2017 do not account for new and emerging information on additional coal retirements since that time. The analysis of each MO therefore first provides base case analysis results, followed by the information resulting from the additional sensitivity analyses and other regional cost pressure.

**BASE CASE METHODOLOGY**

This analysis assesses changes to power generation that would result from the MOs to inform Bonneville's ability to supply adequate and reliable power to its firm power customers under long-term contracts. The analysis considers whether the MOs would result in the need for Bonneville or other regional entities (i.e., wholesale customers who might be receiving less power from Bonneville under an alternative) to acquire power from resources (e.g., new generating plants) and/or construct new transmission infrastructure to replace lost capability at Federal hydro projects. To the extent this analysis identifies potential needs to acquire 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.

action in the future, Bonneville would do so consistent with the Northwest Power Act and complete additional site-specific planning, analysis, and compliance with environmental laws including NEPA.

To the extent that the MOs increase the cost of power generation and transmission (e.g., if Bonneville or other entities need to acquire new sources of power or construct transmission infrastructure), the increased costs would place upward pressure on wholesale and retail electricity rates. The term "upward rate pressure" indicates the potential for increases in rates resulting from the added costs of generating and transmitting power; upward rate pressure could lead to increased rates absent the ability of Bonneville or other entities to balance out the added costs. Likewise, "downward rate pressure" indicates the potential for reductions in rates resulting from decreased costs of generating and transmitting power.

The power and transmission analysis characterizes effects as beneficial or adverse (or no effect, where relevant), considering the following:

- Geographic scope of the effect or the size of the population affected. Because of the interconnected nature of the Pacific Northwest electricity system, changes at one or a subset of CRS projects may affect retail ratepayers more broadly across the Pacific Northwest.
- Relative magnitude of the effect. The intensity of the power and transmission effects refers to the scale of changes in power generation; transmission flows; wholesale power and transmission rates relative to historical levels; and to the costs of living and doing business for residential, commercial, and industrial retail consumers of electricity.
- How an effect persists over time. An effect may be moderate in the short term (e.g., limited to a construction period), but have negligible or no effect over the long term (e.g., beyond the construction period). Most rate pressure effects are long term in this analysis.

The power and transmission socioeconomic analysis considers the effects of the MOs over a 50-year timeframe. However, the quantitative analysis is limited to the period for which information is available to reasonably predict potential effects. The social welfare effects are average annual values of changes in the marginal cost of producing power. These average annual estimates are subject to increasing uncertainty over the 50-year timeframe of the analysis making the analysis difficult on a 50-year timeframe. Therefore, the quantitative regional economic effects are reflected through changes in rate pressure for residential, commercial, and industrial ratepayers over a 20-year timeframe (2022 to 2041), with a qualitative assessment of whether and how effects may persist beyond that timeframe.[22] 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.

uncertainty regarding how the electricity sector will evolve in response to recent and emerging policies (particularly as relates to GHG emissions standards and legislation, as described in Section 3.7) and potential technological growth (e.g., batteries).

Figure 3-173 provides a high-level overview and depiction of the analytical framework. Note that multiple components of the analysis occur within each of the boxes depicted in the figure. Additional detailed methodological information is described further in the step descriptions below and in Appendix H, *Power and Transmission*.

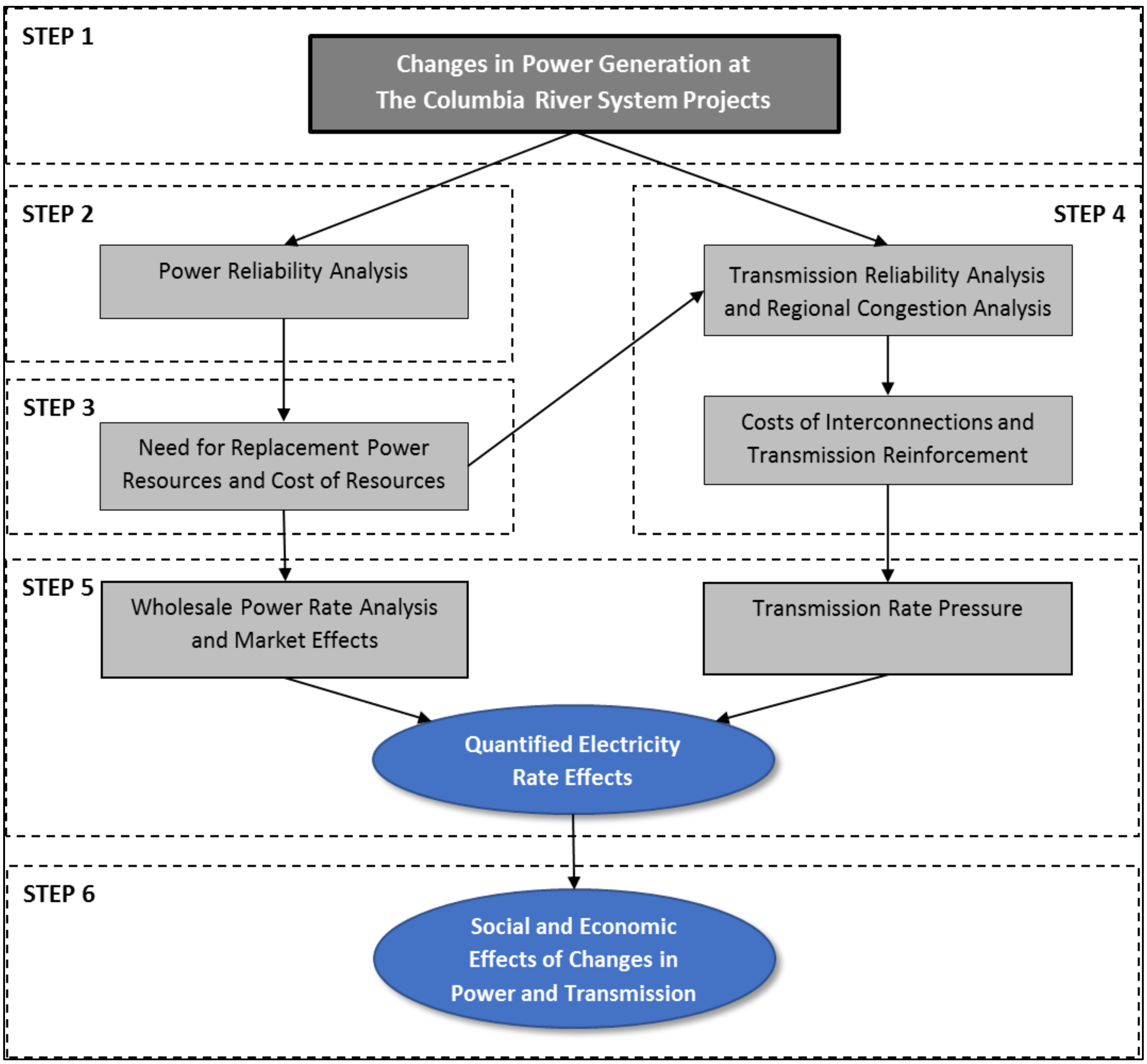


**Figure 3-173. Power and Transmission Analytical Framework**

Note: Additional power and transmission analysis occurs within each of the step boxes depicted.

The stepwise methodology for the power and transmission analysis is as follows:

**Step 1: Estimate Changes in Power Generation.**

The first step estimates power generation from the CRS and other major non-Federal hydropower projects in the region. The Bonneville hydropower simulation model (HYDSIM) model calculates power generation and analyzes that output in 80 different flow years at each of the 14 CRS projects.[23,24] Non-Federal projects on the Columbia are relevant because the timing and volume of flow from the CRS projects would alter downstream hydroelectric generation and affect their overall hydropower output. This step also examines changes to generation under dry conditions. Appendix I, *Hydroregulation*, and Appendix H, *Hydropower*¸ provide more detailed methodological information for this step.

**Step 2: Analyze Effects on Power System Reliability.**

This step considers whether the region has enough power capacity and energy to meet consumer demand (i.e., load). Synthesizing HYDSIM hydropower generation outputs with NW Council load-and-resource forecasts and power-import assumptions, the GENeration Evaluation SYStem (GENESYS) model simulates regional power generation and demand to determine power system reliability. This step estimates the effect of the MOs on power system reliability (i.e., LOLP). If an MO reduces power system reliability relative to the No Action Alternative (i.e., if there is an increase in LOLP), then the analysis continues to Step 3; otherwise, it progresses directly to Step 4.

**Step 3: Determine Need for Potential Replacement Resources and Associated Costs.**

This step identifies additional resources necessary to ensure the Federal power system is able to meet the Administrator's obligations, maintains its power system reliability, and recovers the associated costs of those resources. As described above in Section 3.7.2.9, Bonneville is currently selling firm power through September 2028 under long-term Regional Dialogue power sales contracts. As previously described, under these contracts if a wholesale customer's load exceeds the RHWM, the customer either has Bonneville supply the additional power needed, relies on non-Federal power, or a combination of the two (1) to have Bonneville supply the incremental amount of firm power needed, (2) to use non-Federal power, or (3) to have Bonneville supply part and non-Federal power to supply part of the required amount to serve its load. The contract and Bonneville's current priority firm power rate design (the TRM) is based on the Tier 1 system firm critical output, which is the amount of firm power produced by the Federal hydroelectric dams, Columbia Generating Station, and the output of the non-Federal resources Bonneville has acquired to meet its firm power supply contractual 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.

In the event the Tier 1 system firm critical output decreases, the resulting reduction in system capability can lead to a change in each customer's RHWM, and an increase in its load above the Tier 1 system's ability to supply. This increases the customer above-high-water-mark load, increasing the amounts of power which either Bonneville or the customer is obligated to acquire to meet that load. This step in the analysis identifies what resources might be purchased or acquired and quantifies the cost of maintaining the baseline LOLP for the system. The specific resources that would be developed to maintain a sufficient and reliable supply of power, and how the costs of those resources would be allocated to Bonneville's power rates, are uncertain. To reflect this uncertainty, the analysis considers a range of potential outcomes as follows:

- **Potential Resource-Replacement Portfolios:** This analysis considers two resource-replacement portfolios to maintain a sufficient and reliable power supply. The "conventional least-cost" portfolio chooses the traditional least-cost resources (i.e., least-cost gas-fired resources). The "zero-carbon" portfolio selects the lowest-cost carbon-free resources (e.g., solar, wind, or non-generating tools such as demand response).[25]

  Recent studies by other organizations also examined resource options for replacing resources in the region. .

  A 2017 report released by E3 (2017), assessed the resource options for the northwest if resources with high GHG-emissions profiles are replaced with new resources with the goal of deep decarbonization in the  Northwest, evaluating various policy options for their effectiveness at reducing GHG emissions and their cost. While the report cannot be directly compared to the CRSO EIS, a key finding in the E3 study is that for achieving 80 percent carbon reduction in the Northwest, the least-cost approach is not a 100% carbon free portfolio with new renewable resources but instead consists of a combination of energy efficiency, renewables, and natural gas. The EIS assesses replacing lost hydropower in the MOs with the zero-carbon replacement resources on the assumption that *new* resources would be carbon-free. Existing resources (other than coal-plants slated for retirement) would continue to operate and may decrease or increase generation in response to changes in hydropower generation from the CRS projects and non-Federal hydropower projects in the Columbia River basin.

  In March 2018, the NW Energy Coalition (NWEC) released a report prepared by Energy Strategies Inc. that evaluated the effects of replacing the LSR projects' output using a combination of demand response, conservation measures, utility-scale solar and wind generation, and natural gas. The basic approach of this study was similar to that of the EIS for identifying both a potential least-cost and a potential zero-carbon portfolio for replacing lost hydropower. The NWEC study results were considered in testing the outputs of the EIS analysis. (Section 3.7.3.5 and Appendix H describe the NWEC and compare its results with the EIS analysis in more detail.)

[25] Cost-effective conservation is already included in the No Action Alternative.

This step in the EIS for identifying potential portfolios of replacement resources does not take into account the process for making decisions about replacement resources and acquiring these resources. First, Bonneville and other regional entities would have to decide who is responsible for acquiring the replacement resources. Second, if Bonneville is responsible for acquiring the resource(s), Bonneville would likely need to engage in a lengthy statutory process to acquire that resource.[26] Once these decisions have been made and requirements satisfied, long lead times— potentially a decade—may be required for the planning, permitting, land-acquisition, and physical construction of new generation (e.g., gas, solar, wind, or pumped storage) and new transmission lines.

This step also does not address the additional generation that may be needed to supply balancing reserves to reliably integrate a large amount of new intermittent renewable resources under the zero-carbon portfolio. Generation balancing reserves allow transmission grid operators to adjust the amount of generation in response to changes in load and generation in order to balance load and generation levels and maintain transmission system reliability. The generation output of most new renewable resources is "intermittent" (more variable, e.g., subject to sudden changes in the weather) than dispatchable resources and requires greater amounts of generation balancing reserves to balance the fluctuations in generation levels. In the base analysis modeling, the generation balancing reserves needed for each MO are kept the same as the No Action Alternative. This assumption reflects the uncertainty regarding whether additional generation balancing reserves might be needed to integrate renewable resources. In the absence of a full evaluation of the need for reserves, this analysis provides additional information on the estimated value of needed reserves.

Cost estimates for the potential replacement resource portfolios are based on the NW Council's Seventh Power Plan and Mid-Term Assessment. Annual capital costs described for replacement resources reflect insurance costs, operations and maintenance costs, and debt and interest payments over a repayment period of 30 years.

- **Financing Portfolios:** The effects of acquiring replacement resources on wholesale and retail rate pressures differ depending on the resource-replacement portfolio chosen and 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.

that consider two cost streams for financing the development of these resources. These alternative portfolios affect costs because ownership or rights to the capacity of resources affects how costs would be distributed across ratepayers in the region. One portfolio assumes Bonneville would acquire output from the replacement resources (costs recovered from Bonneville's customers and, ultimately, regional retail ratepayers). The second portfolio assumes regional public utilities would finance the construction of resources, and their costs would be recovered directly from the retail ratepayers of those utilities.[28] The discussion of social and economic effects below examines the rate effects (i.e., extent of upward or downward rate pressure) of various options depending on whether Bonneville or other entities take the lead in acquiring the needed resources. It also addresses the fact that different customers would be affected differently depending on these financing options and by what utility provides their power. Regional utilities that purchase most or all of their power from Bonneville would experience larger effects than IOUs or other public utilities that do not purchase Bonneville power directly. Appendix H, Power and Transmission, provides additional discussion of these issues.

**Step 4: Analyze Effects on Transmission System Reliability, Congestion, and the Need for Infrastructure.**

The Bonneville transmission system analysis relies on power-flow models to assess changes to the flow of electricity on the transmission system under each alternative, including the need for new transmission infrastructure to address any identified system limitations. Because the transmission system is planned to reliably operate during times of peak loading, performance (and the need to reinforce the system to maintain reliable transmission operation) is analyzed during seasonal peak loading times within the region. Replacement resource assumptions (including quantities and general locations) developed under Step 3 were incorporated into the powerflow models to compare the MOs with the No Action Alternative. If the analysis indicated that reinforcement of the system would be necessary with any of the MOs, a transmission network reinforcement to address the identified system limitations was developed and the cost was estimated. Based on the potential replacement resource portfolios identified in Step 3, the analysis also identifies potential additional facilities that would be necessary to interconnect replacement resources to the transmission system associated costs. The developer of the resources identified in Step 3 may have to develop additional transmission infrastructure in order to connect resources to the larger transmission network. The costs of the additional transmission infrastructure would vary depending on the geographical location of the resource with respect to the transmission network, size of the individual project, and other factors.

In addition, the GridView model produces an hourly-congestion forecast for the regional 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

presents and compares the number of congested hours (as defined for this assessment as the transmission path being within 0.1 percent of its current transfer limit[30]) at certain locations on the transmission system[31] for each alternative under three water-flow portfolios (high, median, and low). The congestion analysis uses a 2028 base case[32] that assumes that other generating resources would be used or dispatched in order based on variable cost (i.e., the least-cost resources would be used to produce power before more costly resources were used) to offset hydropower generation changes under each of the MOs. This includes an assumption that coal-fired, natural-gas-fired, and nuclear generators across the Western Interconnection that had not formally announced retirement dates of 2028 or earlier at the time this base case was created would be available for dispatch.

**Step 5: Quantify Effects on Electricity Rates.**

This step translates the effects identified in Steps 3 and 4 into rate pressure for Bonneville's wholesale power and transmission rates, and the resulting effects on retail rates for end users across the region. Specifically, Step 5 evaluates the MOs' impacts on electricity rates by assessing the effect on (1) Bonneville's wholesale power rate pressure; (2) Bonneville's wholesale transmission rate pressure; (3) regional retail rate pressures; and (4) Bonneville's cash flows (i.e., financial analysis).

The analysis of Bonneville's wholesale rates considers multiple variables: (1) the level of generation from the CRS projects and the costs of replacement resources (for either the Bonneville or region financing portfolio), including costs of any new transmission infrastructure; (2) amount of secondary surplus power sales (i.e., the amount of surplus power available for Bonneville to sell in the market) and purchases, as well as changes in transmission sales; and (3) the costs of structural and operational measures relevant to the MOs.

***Power Rate Pressures***

The rates analysis relies on the AURORA model to generate estimates of how much power can be sold into the wholesale market (market sales/purchases in total MWh) and the market price ($ per MWh).[33] Because Bonneville is an actor in the broader regional electricity market, market

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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.

prices are sensitive to fluctuations in Bonneville's sales and purchases. Thus, this analysis quantifies effects on regional utilities that purchase power from the market. It also accounts for effects on the extent to which utilities export power outside of the region (i.e., across the Western Interconnection).[34]

The base case effects on Bonneville's wholesale power rates are provided in each MO under the section heading Bonneville Wholesale Power Rates. The rate pressure effects are provided in two tables for each MO. The first table ("Change in Bonneville's Priority Firm Tier 1 Rate, Bonneville Finances") reflects the extent of rate pressure on Bonneville's wholesale power rates assuming Bonneville acquires resources to replace the generating capability lost due to the respective MO. The second table ("Change in Bonneville's Priority Firm Tier 1 Rate, Region Finances") reflects the extent of rate pressure on Bonneville's wholesale power rates assuming regional customers acquire resources to replace lost capability. The tables include the wholesale power rate pressure effects for both resource replacement portfolio options (zero-carbon portfolio and conventional least-cost portfolio) described in Step 3 against the No Action Alternative (NAA).

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** | | **%** | | **%** |

### *Wholesale Transmission Rate Pressures*

The analysis of wholesale transmission rates calculates the change in transmission rate pressure based on capital costs of generator interconnections, transmission system reliability projects, and effects in transmission sales,[35] which include the impact of market prices and hydropower generation changes. These rate pressure changes reflect the difference between rate pressures under the MOs as compared with the No Action Alternative.

For the socioeconomic analysis, the transmission rate pressure is not applied directly to Bonneville transmission rates but to regional retail electricity rates based on the historical portion of retail rates stemming from the utility transmission costs. The socioeconomic analysis uses the BP-20 transmission customer impact model to distribute the rate pressure

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[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.

geographically. This approach assumes there will not be changes in the type or amount of service taken, the location of additional sales, or changes in Bonneville transmission customers that would impact the geographic distribution. The analysis estimates the effective rate pressure by customer by applying each customer's percent of the overall rate change from BP-20 rates, with any potential service conversion adjustments, to the rate pressure change. This estimate of rate pressure paired with the customer's geographic region provided the input for the geographic rate pressure analysis in the socioeconomic analysis. Additional information regarding sales assumptions used for the transmission rate pressure analysis is included in Appendix H, *Power and Transmission*.

***Retail Rate Pressures***

The effects of the MOs on retail rate pressure (*i.e.*, for rates charged by retail utilities, not Bonneville) would be influenced by changes in Bonneville's wholesale power and transmission rates, as well as changes in market-power purchases. For each MO, the analysis integrates the following elements to evaluate retail rate pressure:

- **Bonneville Power Rate Pressure:** For Bonneville's power customers, changes in wholesale power rates directly affect utility expenditures for the amount of load they serve with Federal power purchased from Bonneville. To estimate the effect on retail rate pressure, the analysis spreads this change in expenditures over total utility load.
- **Bonneville Transmission Rate Pressure:** The analysis first utilizes utility-level data compiled by EIA to identify the share of the "bundled" retail rate that is attributable to the costs of transmission service (EIA 2016, EIA 2019). The analysis then increases that share over time based on the transmission rate pressure estimates that would occur under each MO. The retail rates analysis does not utilize Bonneville-specific transmission rates, instead relying on historical retail rates data to calculate county-level effects based on the transmission rate pressure.
- **Market Purchases:** For all utilities in the region (i.e., Bonneville, its power customers, and non-Bonneville customers), the analysis estimates how potential changes in market power prices and purchases (from AURORA) would affect overall utility expenditures. The analysis then spreads these changes over total load to estimate retail rate pressure.
- **Changes in Regional Power Production Costs**: For all private IOUs in the region, the analysis estimates the change in variable costs (from the AURORA model) from existing natural gas and coal resources. The rates analysis allocates the change variable costs from these resources and spreads them over IOU total load to estimate implications on retail rates.

***Bonneville Financial Analysis***

Included in each MO are the results of a net present value (NPV) calculation of Bonneville's expected future cash flows. The purpose of the financial analysis is to enable comparisons between alternative investment opportunities. The financial analysis quantifies the expected stream of cash inflows and outflows over time and then discounts those cash flows over time to produce a single value representing how much an investment is worth at a specific point in time. Discounting accounts for the time-value of money; a dollar received today is worth more than a dollar received in 10 years. Present value calculations are therefore sensitive to the discount rate used. The Bonneville financial analysis relies on an official agency risk-adjusted discount rate of 7.9 percent.[36]

The financial analysis includes only those cash flows that differ between the various MOs and the No Action Alternative. Ultimately, these cash flows determine revenue requirements and lead to changes in power and transmission rate pressures.

The financial analysis estimates the present value of cash flows over a 30-year timeframe and considers both upfront capital costs for new resources and structural measures, as well as the ongoing costs to operate and maintain these facilities. The analysis also includes the gained or lost revenue due to changes in generation.

Bonneville's official 2019 inflation forecast was used to escalate the annual costs over the 30-year period. Upfront capital costs were stated in 2022 dollars and all capital was assumed to be spent in 2022 for purposes of this analysis. All resource additions were assumed to be available to serve load in 2023. All cash flows were then adjusted to 2019 dollars for consistency with the cost estimates throughout the CRSO EIS.

**Step 6: Assess Social and Economic Effects of the Changes in Power and Transmission.**

This analysis evaluates social and economic effects in terms of the changes in social welfare, regional economic effects, and other social effects. The social welfare analysis relies on modeling outputs and analyses conducted as part of Steps 1 through 4 and the regional economic effects analysis relies on the modeling and rate analyses of Step 5. The analysis and tables in this section present all monetary values in 2019 dollars, relying on inflation estimates from the Bureau of Economic Analysis and Bonneville. Further details on methods and results are presented in Appendix H. Other social effects are assessed qualitatively.

- **Social Welfare Effects:** From an economic perspective, the conceptual basis for measuring economic value is society's "willingness to pay" for a good or service.[37] Absent data to directly measure willingness to pay, it is common to develop estimates based on additional indicators of value, including market prices and replacement costs. This analysis applies two separate methods to estimate social welfare values of the changes in power generation and 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.

effects of changes in power and are presented as changes relative to the No Action Alternative.[38]

The "market price method" for estimating social welfare effects describes the incremental changes in Pacific Northwest hydropower generation (from the HYDSIM model) under each alternative valued at the market price of power (from the AURORA model). AURORA estimates market prices based on hourly demand and operating cost information for each generating plant. The market price method multiplies the average monthly market prices by the monthly changes in power generation and sums over months to estimate the average annual value of the change in hydropower generation under each MO relative to the No Action Alternative. At market equilibrium, the market prices of a good (i.e., power) exactly equals the marginal value to the buyers and the marginal cost to sellers. Thus, the market price method is one estimate of the economic value (i.e., societal willingness to pay) for the lost (or gained) hydropower generation.

However, if the change in output (i.e., power generation) is enough to affect its market price, or if there are structural changes in demand or supply resulting from the MOs, the market prices may not provide a valid measure of the economic value of the change (the market price reflects the marginal cost of power and does not capture the larger cost of new resources when the incremental change in power is not small). In this scenario, the change in hydropower generation may affect market prices and is also subject to structural changes in supply (e.g., replacing hydropower with other sources of hydropower generation). This analysis therefore applies an alternative method of estimating social welfare effects based on the costs of providing equivalent power output under each MO.

This second method, the "production cost method," quantifies the value of the changes in power generation based on the costs of providing an equivalent amount of power (i.e., maintaining reliability for consumers).[39] The production cost method estimates economic effects based on changes in the fixed and variable costs of meeting the regional demand for power. The fixed costs include the annualized capital costs of developing new capacity (i.e., replacement resources) and connecting it to the system (i.e., transmission infrastructure costs). The variable costs included the changes in the cost of fuel, start-up costs, variable operations and maintenance, and, where relevant,

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[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.

emissions penalties in California for the various generating resources across the Western Interconnection under each MO. The production cost method provides a range of results based on the alternative replacement resource portfolios (as described in Step 3).

These two methods are distinct approaches for estimating the social welfare effects of the MOs. Therefore, the resulting value estimates are not additive. The social welfare effects provide a national perspective on the economic effects of changes in power and transmission but do not consider how these changes affect particular populations or regional economies.

- **Regional Economic Effects:** A separate measure of economic effects, the regional economic effects analysis considers the potential for county-level changes in the costs of living and doing business for Pacific Northwest residents and businesses. The analysis additionally presents potential effects outside the Pacific Northwest across the Western Interconnection. The analysis relies on Census data and mapping to establish the geographic area and regional demographics of the potentially affected populations.

  The regional economic effects consider changes in how much residents and businesses would pay for electricity over a 20-year timeframe. This requires estimating the average county-level retail rate and load based on NW Council forecasts. The forecasts for retail rates and loads for residential consumers include low, medium, and high portfolios, which reflect the uncertainty of these forecasts.

  The analysis additionally accounts for end-user responses to price changes (i.e., reducing demand due to a price increase), also referred to as elasticity of demand, which considers the estimated short- and long-term elasticities for residential and commercial user groups based on EIA data.

  The regional economic analysis additionally considers how potential changes in the cost of electricity may affect productivity (e.g., employment and output) across interconnected industries within the regional economy. This may occur, for example, if the increased cost of electricity changes household spending patterns, reducing the demand for other goods and services in the region. This analysis applies IMPLAN to model the increased spending on electricity as a reduction in household income (direct effect) and quantifies the multiplier effects on interrelated economic sectors (indirect and induced effects). IMPLAN is a widely used industry-standard input-output data and software system that is used by many Federal and state agencies to estimate regional economic effects.[40] The underlying data for IMPLAN is derived from multiple sources, including the Bureau of Economic Analysis, the Bureau of Labor Statistics, and the U.S. Census Bureau.

[40] For more information on the IMPLAN® system, visit http://www.implan.com/.

- **Other Social Effects:** The qualitative assessment of other social effects considers how people may be affected by the changes in power and in transmission outside of the estimated social welfare and regional economic effects. This assessment focuses in particular on the potential health and safety effects under each alternative.

A key factor influencing this analysis is the extent of coal plant retirements and their availability to serve regional demand for power primarily by the region's IOUs (relevant to the No Action Alternative and the MOs). The section below highlights this issue and describes how the analysis of each alternative will also explain the sensitivity of the results that rely on base case coal-retirement assumptions formed in 2017 to new information regarding the future availability of coal resources.

**ADDITIONAL POWER RATE SENSITIVITY ANALYSIS AND OTHER REGIONAL COST PRESSURE ANALYSIS**

**Overview of Rate Sensitivity Analysis and Regional Cost Pressure Analysis**

The base case power rate analysis described in Step 5 above relies on a number of assumptions regarding resource availability, resource costs, coal-plant retirements, carbon policies, and other factors that affect the resulting power rate pressure effects. Some of these assumptions have changed or have been updated since the power rate analysis for the base case was developed. Where practicable, the base case analysis has been updated to reflect the most recent information. For other areas, revising the entire rate analysis with the updated or new information was not practicable given timing and analytical constraints. To capture the effect of this new or updated information, additional rate sensitivity analysis is included along with the base case "Bonneville Finances" rate table described in Step 5 above. The specific rate sensitivities addressed include the following:

- Fish and Wildlife Costs
- Integration Services (Hydro Flexibility)
- Resource Financing Assumptions
- Resource Cost Uncertainties (Contingencies)
- Demand Response
- Oversupply

A more detailed description of each sensitivity is provided below in the section heading titled "Rate Sensitivity Analysis Assumptions."

In addition to the base case analysis and the six rate sensitivities discussed above, analysis was performed to assess the impacts of other regional cost pressures, including the potential incremental costs to the region associated with (1) carbon compliance, and (2) accelerated retirement (capital costs and other costs). As discussed more fully below under the heading of "Assumptions Used in Other Regional Cost Pressure Analysis," regional carbon policy changes and updated coal retirement schedules will likely change the resource mix and availability assumed in the base case analysis. Additionally, as carbon policies and coal retirements remain fluid, estimating the potential costs associated with these anticipated changes was too speculative to be included in the rate sensitivity analysis. Nonetheless, as these variables become more defined, they will likely present additional costs to the region. The other regional cost pressure analysis was developed to provide a general assessment for each MO of the potential incremental costs to regional utilities from carbon compliance and accelerated coal retirement. To be clear, the analysis does not present the cost to Bonneville's wholesale power rate alone, and the impact of these variables on Bonneville's rate is uncertain. Instead, this analysis presents a regional view of the potential incremental costs (if known) for the alternative in light of recent carbon policy changes and expected coal retirements.

**Description of Base Case, Rate Sensitivity Analysis, and Other Regional Cost Pressure Analysis Tables**

The results of the base case, rate sensitivity, and other regional cost pressure analyses are presented in each MO under the section heading *Wholesale Power Rates* in two connected tables. The first table, the "Change in Bonneville's Priority Firm Tier 1 Rate, Bonneville Finances" table provides the output of the base case analysis (from Step 5) and the rate sensitivity analysis. This table also combines and summarizes the range of potential rate impacts of the MO on Bonneville's wholesale power rate.

The second table, the "Other Regional Cost Pressure Analysis," table, reflects the incremental cost to the region of the MO in light of potential carbon compliance and accelerated coal retirements. As noted above, this table provides potential regional costs or savings and does not specify what portion of these costs or savings would apply to Bonneville or be recovered in Bonneville's wholesale power rates.

Below is an example of the tables that are included in each MO and the Preferred Alternative with each element of the analysis labeled (Figure 3-174).

**Base Case Analysis**

| | 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 | [illegible] | [illegible] | $ /MWh | $ /MWh |
| Change from NAA due to Costs | $ | % | $ | % |
| Change from NAA due to Load | | % | | % |
| **Total Base Change in Rate** | | **%** | | **%** |

**Rate Sensitivity Analysis**

| | Zero-Carbon Portfolio | | Conventional Least-Cost Portfolio | |
|---|---|---|---|---|
| | $ rate pressure | change from NAA | $ rate pressure | change from NAA |
| **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**

| | Zero-Carbon Portfolio | | Conventional Least-Cost Portfolio | |
|---|---|---|---|---|
| | $ rate pressure | change from NAA | $ rate pressure | change from NAA |
| **Total Base Effect + Sensitivities** | **$ to $** | **% to %** | **$ to $** | **% to %** |

**Other Regional Cost Pressure (annual cost in $ millions)**

**Other Regional Cost Pressure**

| | 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**

### Rate Sensitivity Analysis Assumptions

As described above, the rate sensitivity analysis considers the impact on power rates of six additional cost variables not captured within the base case analysis. Below is a brief description of each variable considered in the rate sensitivity analysis.

#### *Fish and Wildlife Costs*

In 2016, Bonneville's Fish and Wildlife Program budget was $267,000,000, and the Lower Snake River Compensation Plan (LSRCP) budget was $32,303,000 ($281,536,000 and $34,062,000, respectively, when adjusted to 2019 dollars). The Bonneville Fish and Wildlife Program Budget for the No Action Alternative, $281,536,000, was included in the Base Case analysis for each of the alternatives. The Base Case analysis also included $34,062,000 for the costs of the LSRCP for the No Action Alternative, MO1, MO2, and MO4. Upon the breaching of the lower Snake River dams under MO3, Bonneville would no longer have an obligation to fund the operations and maintenance of the LSRCP because Bonneville's funding authority is directly tied to the operation of the lower Snake River projects.

For several of the alternatives, Bonneville analyzed a range of potential Fish and Wildlife Program costs to acknowledge the possibility that some of the alternatives could impact the biological benefits for fish and wildlife and that this could, in turn, change the need for some offsite mitigation[41]. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its Fish and Wildlife program and also acknowledges the uncertainty around the magnitude of biological effects under the various alternatives and the potential impacts on funding, including the timing of funding decisions. For this reason, potential adjustments to the Bonneville Fish and Wildlife Program under MO2, MO3, and MO4 are analyzed separately as part of the Rate Sensitivity analysis.

As previously discussed, funding decisions for the Bonneville Fish and Wildlife Program are not being made through the CRSO EIS process. Future budget adjustments would be made in consultation with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements.

***Integration Services***

As discussed in Section 3.7.2.2, the CRS provides the region flexibility and ramping capability that is important for power and transmission system reliability, meeting load variability, integrating intermittent resources (such as wind and solar), and providing operational reserves for both unexpected generation outages in the region as well as unexpected load deviations. Because LOLP studies can understate the value of this flexibility, analysis was performed to consider this additional value.

The current CRSO EIS estimates for the cost of renewable replacement resources do not include costs for integration services (operating or generation balancing reserves) for the additional variable generation resources. The quantity of generation balancing reserves needed to integrate the renewable replacement resources for each of the MOs was informed by Bonneville's methodologies for forecasting generation balancing reserve requirements. This approach showed that a resource with 100 MW nameplate capacity would require 20-25 MW of reserves and that as the aggregate regional installed solar capacity increases, so does the reserve requirement (measured as a percentage of installed capacity). The sensitivity analysis included here assumes the upper end of this range (25 percent). It is important to note that the FCRPS may only be able to provide roughly 300 MW of additional reserves before non-federal capacity would have to be purchased to meet any additional reserves requirement. Thus, costs could be higher than the current costs estimates for reserves provided by the FCRPS.[42]

To estimate the cost of these generation balancing reserves, Bonneville used the embedded cost of holding capacity from Bonneville's most recent rate case (BP-20 rate case) multiplied by 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.

costs, the upper bound adds the variable costs for regulation and following reserves (at the BP-20 average rate), while the lower bound estimate excludes the variable components of the reserves.[43]

Operating reserve costs also use the BP-20 rates of $9.53/MWh for spinning[44] reserves and $8.32/MWh for supplemental[45] reserves. (Reliability standards require generation to carry 3 percent of expected generation into the next scheduling hour, half consisting of spinning reserves and half as supplemental reserves.)

The expected costs of balancing and operating reserves for the replacement resource portfolios are shown in Table 3-113, Table 3-114, and Table 3-115.

**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** | | | | |
| *MO1* | | | | |
| Conventional Least-Cost | 239,000 | $0.0 | $0.0 | $0.1 |
| Zero Carbon | 2,838,000 | $0.4 | $0.4 | $0.8 |
| *MO3* | | | | |
| Conventional Least-Cost | 6,017,000 | $0.9 | $0.8 | $1.6 |
| Zero Carbon | 6,019,000 | $0.9 | $0.8 | $1.6 |
| *MO4* | | | | |
| Conventional Least-Cost | 1,426,000 | $0.2 | $0.2 | $0.4 |
| Zero Carbon | 11,772,000 | $1.7 | $1.5 | $3.2 |

**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** | | | | |
| *MO1* | | | | |
| 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** | | | | |
| *MO3* | | | | |
| Conventional Least-Cost | 7,047,000 | $1.0 | $0.9 | $1.9 |
| Zero Carbon | 6,019,000 | $0.9 | $0.8 | $1.6 |
| *MO4* | | | | |
| Conventional Least-Cost | 2,854,000 | $0.4 | $0.4 | $0.8 |
| Zero Carbon | 11,772,000 | $1.7 | $1.5 | $3.2 |

**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 |

### *Resource Financing Assumptions*

Resource financing assumptions are a substantial part of calculating the cost of building a resource. The base case analysis includes the cost of building new resources, with assumptions about both interest rate and term. Of these two variables, the base case analysis considers differences in the interest rate costs when either Bonneville or other regional entities replace the resources. The base case analysis, however, does not consider different potential outcomes when the term of the debt repayment is shorter than 30 years, a length of time that likely represents the maximum amount of time that any entity would finance a new generating resource. Importantly, the term of the debt repayment can have a significant impact on retail rates. Hence, it is important to consider how different debt terms can impact this analysis.

While 30 years is about the maximum that most entities would finance a generating resource, the NW Council includes terms as short as 15 years and maximum terms of 25 years for wind and solar resources in its resource pricing model, MicroFin. Fifteen years is most likely appropriate for independent power producers without a rate base to recover the cost when resources run shorter than their expected operating lives. Even from Bonneville's perspective, however, a shorter debt issuance is a potential outcome. For example, certain of the MOs use solar replacement resources that, according to the NW Council are generally financed between 20 and 25 years. Further, by law Bonneville cannot own resources and will need to buy the output from resource owners with potentially shorter time horizons that would ultimately pass on those shorter cost-recovery time horizons to Bonneville. Thus, when considering resource financing assumptions, it is important to consider the cost to ratepayers of shorter financing horizons which would increase the first-year cost to rate payers by 0.3 to 5.6 percent from the base case analysis. Table 3-116 and Table 3-117 summarize the generating resources debt term findings.

**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 |

**Table 3-117. Increase in Annual Costs for Shorter-Term Financing (20-year cost recovery, $ million and in %)(in millions)**

| | Bonneville Finances | |
|---|---|---|
| **Alternative** | **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 |
| | **Bonneville Finances** | |
| **(in %)** | **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% |

***Resource Cost Uncertainties***

The overnight capital costs for the replacement resources in this analysis were the mid-point from the NW Council's 7th Power Plan Mid Term Update.[46,47] In this mid-term update, the NW Council updated the capital costs of solar and single and combined cycle gas turbines. Because only the single mid-point was used in the CRSO EIS analysis there are resource cost uncertainties that could result in higher and lower cost outcomes for the MOs.[48] In Table 3-118, the zero-carbon portfolios for MO1, M03, and M04 reflect the resource need for solar in megawatts and the ranges of potential capital costs in dollars per kW, using the resource cost uncertainties estimates.

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[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.

**Table 3-118. Solar Resource Need (MW) for the Zero-Carbon Portfolio and Potential 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 |

Note: 1/ Midterm Assessment of the 7th Power Plan page 6-4 (Solar Photovoltaic)

In Table 3-119, the conventional least-cost portfolios reflect the need for replacement resources for natural gas fired power plants. The differences in capital costs of M03 compared to M01 and M04 reflect that a combined cycle power plant was more cost-effective for MO3 than the single cycle plants selected for M01 and M04. It is not cheaper in terms of capital costs, but rather more cost-effective in terms of being a more efficient unit that has a better heat rate (uses less fuel per unit of electrical energy created).

**Table 3-119. Natural Gas Resource Need (MW) for the Conventional Least-Cost Portfolio and 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 |

Note: 1/ Midterm Assessment of the 7th Power Plan page 6-4 (MO1 and M03 Frame GT; MO3 CCCT Adv West Cooling)

***Demand Response Analysis for CRSO***

Many utilities have proven success in leveraging demand response as a tool for summer/winter peaking and load-shifting, for deferment of transmission or distribution investments, or for economic purposes in times of high market prices. It is generally recognized that there are two types of demand response (DR): (1) firm DR capacity, and (2) non-firm DR capacity. Firm DR capacity generally includes all types of Direct Load Control, Third Party DR contracts (where the service provider has an obligation for performance) and Irrigation. Firm DR has hour and frequency-of-use limitations, depending on the load type. Non-firm DR capacity includes pricing strategies and behavioral demand response in which the utility is dependent on consumer action to achieve a capacity goal. Bonneville only considers firm DR capacity in evaluating substitutes for firm generation.

**Assumptions Used in Base Case Analysis**: The CRSO base case analysis uses the NW Council's 7th plan for costs and amounts of achievable demand response. Consistent with the 7th Power Plan's estimates, the analysis assumes 400 MW of demand response developed in the near-term by Bonneville, in partnership with Bonneville's power customer utilities, and another 200 MW of demand response developed by regional investor owned utilities.

The lowest cost demand response product identified for the 7th Power Plan had a twenty-year levelized cost of $45/kW-Year (2012$), which is the value assumed in the base case rates analysis. The NW Council's levelized costs include all costs[49] required to continually implement the demand response over the twenty-year NW Council planning period. The 7th Power Plan identified additional technically and economically achievable regional demand response available at higher costs up to $55/kW-year.

**Rate Sensitivity for Demand Response:** Demand response is an innovative and economical means for displacing peaking resources by shifting load and thus meeting future planning needs. New technologies are continually improving demand response, reducing its costs and increasing its effectiveness. At the same time, demand response at levels assumed in the base case analysis remains largely untested. In the Pacific Northwest, demand response has occurred primarily through pilot programs at levels below the scale assumed in the base case analysis. As such, there is uncertainty around the ability of demand response to manage load variation, resource integration, and operation and generation balancing reserve needs at the levels needed to replace lost generating capability for some of the MOs. To quantify these uncertainties, a demand response sensitivity was included in the rates analysis to address two variables: (1) cost of demand response; and (2) availability of demand response.

The cost variable updates the demand response cost assumptions used in the base case analysis (data from the 7th Power Plan[50]) with more recent study information.  Specifically, the Cadmus Group performed a study that found that demand response, consisting of both for Firm and non-firm demand response actions, could be achieved for as low as $17.31/kW-year (2017$) in the region in the near term. (Cadmus Final Report, 9/20/19, pages xi and 30).[51] If the Cadmus cost assumption is used, the cost of demand response is reduced compared to the base case analysis. The Cadmus Group's analysis is presented as a "low end" sensitivity, and not a replacement for the cost data from the 7th Power plan, because the Cadmus Group cost estimate includes both Firm and non-Firm forms of demand response (whereas the 7th Power Plan differentiated between Firm and non-Firm).

The second variable considered in the demand response sensitivity was availability. The base case assumes that Bonneville and the region would achieve 600 MW of firm demand response, 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.

unprecedented regional achievement. At the same time, there is uncertainty as to the effectiveness and achievability of demand response in the size assumed in the base case analysis. To reflect this uncertainty, the demand response sensitivity includes an "upper end" cost sensitivity to reflect the potential change in resource replacement costs if some of the firm demand response included in the base analysis were unavailable and alternate, more expensive, resources were needed. The upper end of the demand response sensitivity analysis assumes as much as half of demand response (300 MW) would be replaced by a combination of solar resources and battery technology.

***Oversupply***

Bonneville uses the Oversupply Management Protocol (OMP) to moderate TDG levels in the Columbia River to protect endangered fish and other aquatic species. The requirements and procedures for OMP are contained in Attachment P to Bonneville's Tariff. Oversupply typically occurs in the spring when there are high flows. High flows require spilling water, which increases TDG levels, or passing water through generating turbines, resulting in increased hydro generation. Due to low demand in the spring, it is often challenging for Bonneville to find additional load for any increased hydro generation. Without additional load, Bonneville must spill water. In order to moderate TDG levels that occur from additional spill, Bonneville increases hydro generation by implementing OMP to displace non-Federal generation in its BAA using a least-cost displacement cost curve. Bonneville takes a number of actions to reduce or avoid the need for displacement, including selling power down to zero cost.

OMP costs can vary substantially from year to year with different hydrological conditions and associated hydro generation, in addition to the amount of non-Federal generation running in the BAA. Generally, in low water years, oversupply events are relatively unlikely, while in high water years – particularly those with high spring runoff flows – oversupply events are more likely. Thus, Bonneville generally does not forecast the expected costs of OMP. Bonneville charges a separate rate to recover any actual costs associated with implementing OMP.

In the CRSO analysis, no provision for recovery of OMP costs is included in base power rates. However, OMP does present a potential source of rate pressure which could differ materially based upon water conditions, the supply constraints on the FCRPS associated with each alternative, and the potential of locating replacement resources in Bonneville's BAA. To price oversupply events under each of the MOs, Bonneville used the average historical price paid to generators displaced for FY2012–FY2019. This price, 29.22$ per MWh, is based upon actual costs incurred, and is a reasonable predictor of costs which might be anticipated in the future. This average price is applied to the expected magnitude of oversupply needs based upon the 3200 modeled iterations for each alternative and replacement scenario. Since AURORA is able to determine the incidence of oversupply events based upon whether modeled clearing prices are less than zero, expected magnitudes can be reasonably forecast. To establish the range of expected costs, the 10th and 90th percentiles are used.

**Assumptions Used in Other Regional Cost Pressure Analysis**

The other regional cost pressure analysis evaluates incremental costs that, while speculative now, are likely to have broad implications on power costs for the region in the future. Provided below are descriptions of the cost of carbon compliance and availability of coal resources, which are the two cost pressures included in the "Other Regional Cost Pressure Analysis" table.

***Cost of Carbon Compliance***

Several states in the western U.S. have passed, or are likely to pass, legislation directed at decarbonizing the electric grid. California began implementing an economy-wide cap-and-trade program in 2013. In 2018, the California legislature passed a law seeking to achieve 100 percent carbon-free electricity by 2045 (Senate Bill 100). Washington enacted the Clean Energy Transformation Act (CETA) in 2019, requiring that Washington utilities eliminate coal costs from their retail rates by 2025. CETA also directs Washington retail utilities to serve loads with 100 percent carbon-neutral power by 2030, and 100 percent carbon-free power by 2045 (RCW 19.405). Oregon has been considering a cap-and-trade program similar to California's program. Additionally, Nevada (Senate Bill 358, 2019) and New Mexico (Senate Bill 489, 2019) both adopted 100 percent carbon-free goals for the electricity sector. The province of British Columbia has had a carbon tax in place since 2008.

The legislative trends suggest that in the future there may be a cost associated with most or all fossil-fuel-generation located in or serving load in the Pacific Northwest. At a minimum, starting in 2030, there will be a cost to fossil fuel generation used by utilities to serve retail load in Washington, which accounts for over 50 percent of total regional load (EIA 2017).

The MOs in the CRSO EIS would affect the amount of hydropower production in the region, which does not in itself generate greenhouse gas (GHG) emissions. Hydropower production levels, however, will affect the fuel mix and overall GHG emission levels from the regional electricity sector. This is because existing resources (other than coal-plants slated for retirement) continue to operate and may decrease or increase generation in response to changes in hydropower generation from the CRS projects and non-Federal hydropower projects in the Columbia River basin. Changes to GHG emission levels would impact states' abilities to meet GHG emissions reduction targets. Such changes would also affect compliance costs for utilities, and ultimately ratepayers, under policies that mandate a price on GHG emissions. This analysis considers how the MOs could affect regional utilities' cost of compliance with the GHG emissions reduction policies mentioned above. The analysis is forward-looking to the early 2030s when Washington's CETA will be in effect as well as giving time for implementation and maturation of potential additional GHG emission reduction policies.

The analysis presents a low and high estimate of how the MOs could affect the regional cost of compliance with GHG emission reduction policies. The low assumption uses the auction reserve price (the floor) for California's cap-and-trade program to represent a conservative price on carbon in the early 2030s. The 2019 auction reserve price is $15.62 per allowance and rises annually by 5 percent plus the rate of inflation. An allowance is the compliance instrument that entities acquire for one metric ton of $CO_2$ equivalent (MT $CO_2e$). This analysis estimates that in 2030 the auction reserve price will be $33.77, meaning that this would be the cost equated to one MT $CO_2e$. The high assumption uses the administrative fee under Washington's CETA to represent a reasonably high price on carbon in the early 2030s. Under CETA, the administrative fee applies to each MWh of emitting generation. The fee is $150 per MWh for coal-fired resources, $84 per MWh for gas-fired peaking plants, and $60 per MWh for gas-fired combined-cycle plants. Starting in 2027, these fees rise annually at the rate of inflation. This analysis estimates that in 2030 the CETA administrative fee will be $162.54 per MWh for coal-fired resources, $91.02 per MWh for gas-fired peaking plans, and $91.02 per MWh for gas-fired combined-cycle plants. For comparison, this is similar to the price ceiling for California's cap-and-trade program, which this analysis estimates will be around $121.84 in 2030, which could be a closer indicator than the reserve (floor) price of future allowance prices in California and similar cap-and-trade programs as the supply of allowances tightens in the future.

Consistent with the air quality and power analysis in Sections 3.7 and 3.8, emissions and resource amounts are based on the 2022 AURORA power markets model outputs. Potential future coal plant retirements present a source of uncertainty and to the extent coal generation is replaced by natural gas and renewables the estimates in Table 3-120 may overestimate the cost of compliance. However, this analysis also errs conservatively on the price of carbon by using prices in the year 2030 even though prices will continue to annually escalate beyond then.

**Table 3-120. Annual Change in Cost of Compliance with GHG Emissions Reduction Policies for 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 |

This analysis does not consider the impacts that the MOs would have on Bonneville's fuel mix should Bonneville acquire the replacement resources. To the degree that replacement resources may cause Bonneville's fuel mix to include more carbon that would impart a regulatory cost onto utilities that purchase from Bonneville and are subject to state carbon-pricing programs such as CETA. This analysis also does not consider how changes in Bonneville's fuel mix (and accompanying changes in the carbon content attributed to Bonneville's power sales) could impact the value of Bonneville's surplus sales to states outside of the Pacific Northwest with GHG emissions reduction programs, such as the value of surplus sales to California. Lastly, this analysis is distinctly different than the social cost of carbon analysis in Section 3.7. The values in Table 3-120 above represent a regulatory cost that is directly borne by regional utilities and ratepayers resulting from changes in the regional electricity sector's fuel mix and GHG emissions. In contrast, the social cost of carbon calculates the economic harm resulting from the impacts to society that GHG emissions impose on a global scale.

### *Availability of Coal Resources*

Energy economics and state and local de-carbonization policies are changing the generation portfolio in the region and across the Western Interconnection into the 2020s and beyond. Therefore, the base case analysis for the power and transmission analysis in the CRSO EIS, established at the outset for modeling in 2017, no longer reflects the current understanding of resources that will be available to serve load in the future. Additional and accelerated coal retirements have been announced and more are being contemplated, mainly impacting the region's IOUs, which use these resources to serve their retail loads.

The urgency of regional resource adequacy was made clear in a March 2019 report written by E3 (2019) on behalf of Puget Sound Energy, Avista, Northwestern Energy, and the Public Generating Pool. According to E3, the retirement of coal power supplied to the Northwest states threatens to create an electric power supply shortage of up to 8 GW by 2030. Regional utilities, including Bonneville, have begun working together to address the issue.

CETA mandates the elimination of electricity produced by coal used by all utilities in Washington by 2025 (Washington SB5116, 66th Legislative Session, 2019 Regular Session). The Oregon Clean Energy and Coal Transition Act (2016) mandates the elimination of the cost of coal resources in retail rates of IOUs by 2030 (Oregon SB1547, 78th Legislative Assembly, 2016 Regular Session).

The No Action Alternative assumes 1,675 MW of retired coal capacity and a continued coal capacity of 4,246 MW. This is the assumption underlying the base analysis and the results presented in this section, except where otherwise noted. To understand the implications that additional coal retirements would have on available replacement resources and resource adequacy in the region, this EIS considers two scenarios that address additional coal plant retirements: The first scenario is **"limited coal retirement."** This analysis represents retiring an additional 2,505 MW of coal generation compared to the No Action baseline (Table 3-121; Section 3.7.3.2, Table 3-132). This assumption represents coal plants that have been announced to retire in the 2020s. Under this scenario, only Colstrip unit 4 and Jim Bridger units 3 and 4 remain. The second scenario assumes the retirement of all coal plants operating in the Northwest or serving Northwest loads (**"no coal"**)(Section 3.7.3.2, Table 3-132).

**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** |

Note: The generation values represent the expected annual generation of the plants allocated to serving Northwest loads. Thus, the listed generation values are not the full nameplate capacity of each plant.
1/ Generation values are from the NW Council's generation resources database for regional studies.

These two scenarios provide an updated understanding of the differences between the CRSO alternatives and costs of zero-carbon replacement scenarios by modeling LOLP in light of the additional coal plant retirements. However, it is important to recognize that this EIS focuses only on coal retirements; it does not attempt to analyze the impact of removing natural gas plants in Washington or other states in the 2020s and beyond as may result from 100 percent carbon-free electricity standards like the CETA. Accordingly, the analysis on phasing out coal-fired generation assumes that no *new* gas-fired generators would be constructed in the region.

**Qualitative Considerations of Alternatives on Competitiveness of Bonneville's Firm Power Rates**

The rates analyses discussed for the MOs below provide a snapshot of the power rate pressures resulting from the MOs. These analyses, however, do not evaluate the potential long-term impacts of the MOs on the competitiveness of Bonneville's power rates. This additional consideration is described here as a general qualitative impact of the MOs but is not quantified in the rates analyses.

The MOs' long-term cost impacts on Bonneville's wholesale power rates is an important qualitative consideration because of the competitive nature of the industry Bonneville operates in. Bonneville is statutorily obligated to offer power (which includes the CRS projects) if requested to meet its preference customers' power requirements. However, these utilities are not required to purchase Federal power from Bonneville and therefore will have a choice in selecting a new power supplier upon the expiration of their current power sales contract in 2028. Retaining Bonneville's preference customer base will be critical to assuring Bonneville is able to meet its public purposes and financial obligations for the long term. Federal power sales to preference customers are an essential source of revenue for Bonneville, making up approximately 80 percent of Bonneville's power revenue. The rates these customers pay recover the vast majority of the costs of the Federal investment in the FCRPS, including the costs of mitigating the effects of the hydroelectric power system on fish and wildlife.

Bonneville's preference customers have expressed concern about the long-term competitiveness of Bonneville's wholesale power rates. These concerns prompted Bonneville to take actions that will reduce its costs and change its 2009–2019 rate trajectory (power rates increased by roughly 35 percent during this time). With these actions, Bonneville is now on a sustainable rate trajectory. However, additional rate pressures that result from changes to the

FCRPS that increase Bonneville's costs, or reduce its revenues, would further challenge Bonneville's new rate trajectory. Ultimately, significant additional rate pressure could overwhelm Bonneville's ability to take corrective actions and could jeopardize Bonneville being the competitive supplier of choice for preference customers' in the post-2028 period.

The possibility that Bonneville's traditional firm power customers (preference customers) may seek other suppliers because of the rising cost of Federal power presents important qualitative considerations for the power rate impacts discussed in the MOs (as well is in the analysis of the Preferred Alternative in Chapter 7). If preference customers choose to reduce their Federal power supply because of cost pressures, Bonneville would sell larger amounts of surplus power (firm and seasonal) into the wholesale power market and/or for periods up to 7 years as Excess Federal Power[52] both within and outside the Pacific Northwest. These sales would likely occur at the prevailing market prices for power, which could be above or below Bonneville's actual costs. Quantifying the revenue from these potential surplus sales of power is difficult because it is dependent on the amount of firm power requested by preference customers after 2028.

Because of the difficulty with forecasting Bonneville's future long-term sales, and the percentage of preference customers comprising these sales, this risk is presented as a qualitative risk. These qualitative considerations would include, among others, the ability of Bonneville to continue to fund major infrastructure. For example, if Bonneville must rely on surplus sales to recover its costs, which are an inherently more volatile source of revenue, Bonneville would have to become much more conservative when considering capital investments and potentially defer investments that otherwise would have been made per Bonneville's asset management strategy. Bonneville also would likely be more cautious about committing to spending for fish and wildlife programs and other financial obligations beyond current budgets intended to maintain Bonneville's current rate strategy. This follows from the limitations of selling Federal power at prevailing market prices, which may be below Bonneville's fixed costs.

Bonneville anticipates that sustained cost discipline between now and the expiration of power contracts in 2028 will help mitigate the risk of a substantial loss of firm power sales to preference customers due to competitive pressures. For this reason, the long-term competitiveness of Bonneville's power rate is an important qualitative consideration that should be considered in conjunction with the rate pressures identified for each MO and the Preferred Alternative—particularly in alternatives with significant rate pressure.

#### *3.7.3.2 No Action Alternative*

This section evaluates power and transmission effects under the No Action Alternative. "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.

under the operations rules in effect in September 2016. The analysis below projects generation and reliability of the regional power system through 2041. It accounts for planned maintenance at CRS projects in future years, load and resource forecasts, and planned retirements of coal power plants as of 2017 (i.e., base case assumptions).

**CHANGES IN POWER GENERATION**

Average power generation would minimally differ from current conditions. Average annual generation in the CRS is at 8,300 aMW (for reference, according to the NW Council, 1 aMW can power about 796 Northwest homes for a year). Several hydropower-generation statistics are useful in presenting effects to make comparisons between the No Action Alternative and the MOs. The first is monthly generation (Table 3-122) from the CRS projects, which peaks during high spring run-off and then decreases over the year through the fall. The second is peak- and heavy-load generation.[53] For the No Action Alternative, the annual average peak load period generation of CRS projects is 11,000 aMW, and the annual heavy-load period generation is 8,800 aMW. Hydropower in the region (including CRS projects as well as other Federal and non-Federal projects) generates 13,000 aMW on average of the historical water years. Appendix H provides detailed generation results by project and for all water years modeled. Generation under critical water conditions (1937) for the CRS projects decreases by 300 aMW.

**Table 3-122. 80-Year Average Monthly Average Electricity Generation (aMW) at the Columbia 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 |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves. Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

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.

**EFFECTS ON POWER SYSTEM RELIABILITY**

Based on load forecasts, limited coal plant retirements, and changes in power generation, the No Action Alternative would result in an LOLP of 6.6 percent in 2022. Although this exceeds the current NW Council target of 5 percent, the scope of the CRSO EIS analysis does not address the resources that might be needed to achieve the NW Council target under the No Action Alternative.[54] The scope of this EIS compares the MOs to the No Action Alternative.

This LOLP estimate relies on an assumption about the resources available to serve regional loads over time that has changed since the initiation of this analysis. The basis for that assumption is the NW Council's resource adequacy dataset developed in 2017. While it accounts for the planned coal plant closures known at that time, it also assumes coal plant generating capacity (4,246 MW) would continue to serve primarily regional IOU loads.

Since the NW Council developed the dataset applied in this analysis, multiple additional or accelerated coal plant closure plans have been announced, as described in the Section 3.7.3.1 above. Table 3-123 presents results of an analysis with updated assumptions on the level of coal capacity primarily available to serve regional IOU loads for power system reliability. The analysis considers two possible future conditions: (1) closure of most, but not all, coal plants given coal retirements announced and/or accelerated since 2017 (1,741 MW of coal remaining), and (2) complete removal of all coal capacity (0 MW of coal remaining). The analysis considers the effects of these assumptions on the LOLP and the annual fixed cost of a zero-carbon replacement portfolio (demand response, wind, solar, and storage [i.e., battery technology and pumped storage]) to restore power system reliability.

This analysis finds that the power and transmission effects are very sensitive to assumptions regarding the coal generating capacity that would be available to serve regional loads. The coal plants are considered "base-load" resources and can be turned on or off (i.e., dispatchable) as needed to serve load. In contrast, intermittent resources like solar and wind under development in the region are not dispatchable, which means they may not be able to generate to meet demand. Even under the No Action Alternative, the LOLP levels are considerably higher with reduced generation from coal. With more limited coal-plant capacity, the LOLP is 27 percent. Assuming that no coal capacity remains, and without resource development, this analysis finds that rolling blackouts would occur in the region in two out of every three years.

While there may be additional means to maintain power system reliability over time (e.g., transmission infrastructure changes or new technologies), how this would be accomplished is uncertain. Appendix H includes a more detailed description of this analysis.

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[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.").

The loss of baseload coal resources and replacement of those resources with new renewable resources, such as solar power, under these coal-closure scenarios changes the amount of additional resources needed to replace lost hydropower generation from the MOs compared to the No Action Alternative. Therefore, Table 3-123 shows a representative potential portfolio to give an idea of what might be needed to restore the LOLP of the No Action alternative to 6.6 percent. The effects for each MO are discussed in their respective sections following this discussion of the No Action Alternative. For a sense of scale, the region currently has under 1,000 MW of installed solar capacity both utility and small scale.

**Table 3-123. Coal Capacity Assumptions, Zero-Carbon Replacement Resources for All Alternatives**

| | Base Case Coal Capacity Assumption in EIS (4,246 MW) | | | More Limited Coal Capacity (1,741 MW) | | | No Coal Capacity (0 MW) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Alternative** | **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 |

Notes: The replacement resources for the No Action Alternative include demand-response, wind, and solar; for MO3, the analysis additionally includes storage technology (e.g., batteries, pumped storage). The incremental resource builds under the more limited coal capacity or no coal capacity are additive with the resource builds under the base case.

## POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS

Given the key assumptions described above for the base case analysis (including continued coal capacity), the analysis finds that no replacement resources would occur under the No Action Alternative, though higher than the NW Council's standard of 5 percent, the 6.6 percent LOLP is within the reasonable historical range of the NW Council target.

Note the coal capacity analysis only analyzes the effects from limited to no coal capacity on the LOLP and the potential size of a zero-carbon replacement. The analysis of rate effects presented below relies on the base case assumptions without the additional coal plant retirements. The detailed analysis does not address the additional generation balancing reserves needed to integrate large amounts of new renewable resources but does add an estimate of this value to the calculation of the rate pressure. Generation balancing reserves allow grid operators to increase or decrease generation in response to changes in load and generation to ensure instantaneous balance between load and generation. The generation output of renewable resources is more variable (subject to sudden changes in the weather) and requires more generation balancing reserves to balance load and generation levels. In this analysis, the generation balancing reserves needed for the No Action Alternative are included in all modeling. However, the additional reserves needed if large amounts of renewable resources (such as wind and solar) are added have not been addressed. These reserves can be supplied through the hydropower system if the system has enough flexibility, or from gas-fired generators in the region. With further technological advances and substantial increases in power storage capacity, other options may be available in the future. Based on the outcome of this EIS, if Bonneville requires additional generation balancing reserves, it would evaluate how to acquire these resources in a separate process or processes (that would include appropriate NEPA review) subsequent to the CRSO EIS process.

For the scenario with the more limited coal capacity, the LOLP of the No Action Alternative rises to 27 percent. This value would represent having power shortages in nearly one of every three years and would require the region to acquire new resources to replace the coal generation. While the scope of the CRSO EIS analysis is not necessarily to address resource adequacy issues related to the No Action Alternative because the coal-plant retirements are not serving Federal load, resource acquisitions made by the region for the coal-plant retirements will affect how changes in CRS hydropower would impact the region. Therefore, for the scenarios with more limited or no coal capacity, the CRSO EIS estimated the amount of zero-carbon resources that would be needed to return the LOLP of No Action alternative to the level before the additional coal plant retirements, i.e., to 6.6 percent. If the retired coal capacity is replaced with natural gas power plants, then it would take about the same amount of new gas plant capacity as the amount of retired coal capacity. However, because the regional policy and legislative direction is not to build new carbon-emitting resources, the EIS examined what the resource build might be for zero-carbon replacement resources. As shown in Table 3-123 for the case with more limited coal capacity, the region would need about 8,800 MW of new zero-carbon resources; for the case with no coal capacity, the region would need about 28,000 MW of new zero-carbon resources.

When baseload resources are replaced by intermittent resources such as wind and solar generation, the nameplate capacity of the replacement resources must be higher than the capacity of the baseload resource that is retired. This stems from two similar effects. On average, an intermittent resource generates less than its nameplate capacity because it is not always windy and sunny. Furthermore, an intermittent resource does not generate its average output at all times, is seasonal in nature, and is often generating less (or nothing) at times of greatest need. Thus, the intermittent resources that replace baseload resource capacity need to have greater nameplate capacity than the baseload resource they are replacing to meet all of the demand. This is why in the No Action Alternative, the zero-carbon resource builds in Table 3-132 are much higher than the amount of coal retirement in the two scenarios. In the Pacific Northwest, the hydropower system can often reduce generation when wind and solar generation are abundant and increase generation when wind and solar are not generating as much. Without the hydropower flexibility, the region would probably need even more zero-carbon resource builds to replace the retired coal generation. Operating constraints on the hydropower system limit the extent to which hydropower generation can adjust to complement wind and solar generation.

#### BONNEVILLE FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION PLAN COSTS

The summary rate table for the Base Case analysis includes an estimate of approximately $339 million in annual costs for the Fish and Wildlife Program and LSRCP combined for the No Action Alternative. In 2016, the Bonneville Fish and Wildlife Program spending level was $267,000,000 and the LSRCP spending level was $32,303,000 (BP-16 Rate Case). Adjusted to 2019 dollars, these spending levels are $281,536,000 and $34,062,000, respectively.

#### EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE

##### Bonneville Transmission System Interconnections, Reliability, and Operations

Under the No Action alternative, Bonneville would continue to maintain transmission system reliability by providing proper voltage for delivery of energy to expected loads in the 10-year planning horizon (and beyond) while keeping transmission loadings within required limits. Thus, the analysis did not identify any additional Bonneville transmission capital costs or transmission system reliability issues under the No Action Alternative beyond those activities that Bonneville already identifies in its regular system assessments. Due to expected increases in loads in the Tri-Cities load service area, Bonneville's regular system assessments have identified several transmission reliability projects that are anticipated to occur within and beyond the 10-year planning horizon.

##### Regional Transmission System Congestion Effects

Under the No Action Alternative, nine regional transmission paths would experience some hours of congestion at some point in the year in at least one direction under the various flow conditions.

The greatest number of congested hours under the No Action Alternative would occur on the Hemingway to Summer Lake transmission path. This path would have 1,412 hours of west-to-east congestion in the high-runoff case due to increased hydro generation. The Hemingway to Summer Lake path contains one transmission line (the Hemingway to Summer Lake transmission line). The Idaho to Northwest transmission path, which consists of five high-voltage transmission lines in Idaho and Oregon including the Hemingway to Summer Lake transmission line, also exhibits west-to-east congestion during median and high runoff cases. [55]

Congestion would also occur on five paths that can exhibit congestion in the north-to-south direction depending on flow patterns. The Pacific DC Intertie, which runs through Oregon to the Oregon/Nevada border (where the Bonneville owned portion ends) and continues to the Los Angeles area under non-Bonneville ownership, would experience the highest frequency of congestion, accounting for between 442 and 620 hours of the north-to-south annual congestion hours. This congestion forecast is likely conservative because it estimates a highly optimized power system and does not account for unplanned outages, maintenance, or other circumstances that affect the transmission system and may result in congestion. Thus, if an unplanned outage, routine maintenance, or other circumstances occurred, the effects to congestion would be greater than described above

Transmission system reliability is expected to be maintained under the No Action Alternative despite congestion on these paths. Detailed graphs depicting the number of hours of congestion along the individual paths under different water years appear in Appendix H.

**ELECTRICITY RATE PRESSURE**

As explained below, the No Action Alternative analysis identifies that potential rate pressure over time would be in line with recent trends.

**Bonneville Wholesale Power Rates**

Based on the modeled rate pressures under the No Action Alternative, the average wholesale rate for firm power may be around $34.56 per MWh in 2019 dollars. This represents the average rate paid by Bonneville's preference customers in the No Action Alternative and not the effective rate paid by a particular Bonneville customer[56] nor is it the actual or forecast rate in Bonneville rate cases.

**Market Prices**

Estimated average exports would amount to roughly 910,000 MWh (190 aMW) of sales during 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.

light load hours[58] per month. The average price for power traded at the Mid-Columbia trading hub is forecast to be $21.02 per MWh for heavy load hours and $16.66 per MWh for light load hours (2019 dollars). The overall average market price would be $19.42 per MWh (2019 dollars). This value would fluctuate throughout the year in relation to streamflow, generation, demand, and market factors. Figure 3-175 shows the average market price and average Federal hydropower generation by month.

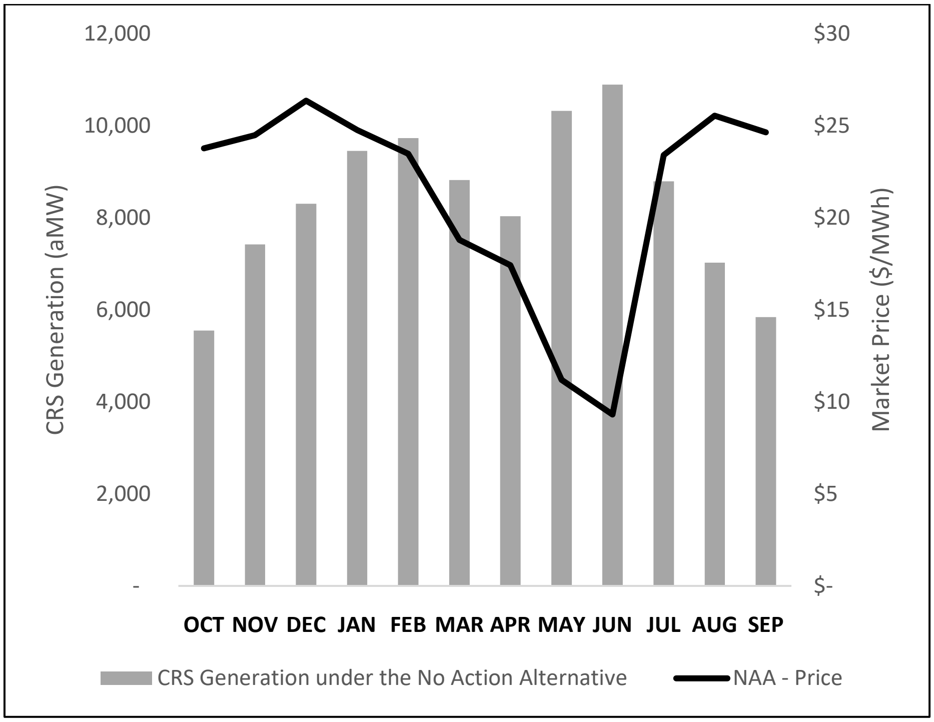


**Figure 3-175. Monthly CRS Generation (aMW) and Market Price ($/MWh)**

Note: The right axis is the market price ($/MWh). The left axis is generation from the CRS projects by month (aMW). Source: Power Analysis 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.

It is important to note the difference in value between wholesale spot market prices and Bonneville's wholesale power rates. Power traded in the spot market is often between marketers and utilities and is generally surplus to a utility's needs or produced by a merchant plant owned by an independent power producer. Bonneville trades in the spot market, meaning that it purchases power and sells its surplus power when available and economical to do so. The revenues from Bonneville's surplus sales and purchases are credited back to its wholesale power rates. However, the product sold at spot market prices is not the same as the product sold at Bonneville's wholesale power rates. The spot market cannot be counted on as being available on a guaranteed long-term basis, it does not follow load, and does not include many other attributes found in Bonneville's wholesale power products (*e.g*., low-carbon, energy loss returns, an energy efficiency incentive, scheduling). When customers buy power from Bonneville under firm, long-term contracts, they receive these other attributes and are assured that Bonneville will supply them with the power they need. Consequently, the power product Bonneville sells to its preference customers under long-term power sales contracts has higher value (and can have a higher average cost) than the power products sold in the spot market.

In addition, it is important to note that the Pacific Northwest is currently experiencing historically low natural gas prices. These prices are currently forecasted to remain low. As such, this analysis may underestimate energy costs should natural gas prices increase in the future.

**Bonneville Wholesale Transmission Rate Pressure**

Under the No Action Alternative, there would be no changes assumed in capital investments or in transmission sales compared to the current 8-year baseline (through 2029). Therefore, the Bonneville transmission wholesale rates would not likely deviate from current long-term conditions, meaning no additional transmission rate pressure attributable to the No Action Alternative.

**Retail Rates**

Under the No Action Alternative in 2022, based on the modeled rate pressure, the estimated average regional residential, commercial, and industrial retail rates for the region would be 10.21, 8.89, and 7.25 cents per kWh, respectively. These estimates are derived from unbundling the retail rate into key components: power generation, distribution, transmission, and other administrative costs. Figure 3-176 provides an example of this disaggregated retail electricity rate based on 2016 data from financial reports at FERC compiled by the EIA. The analysis of the transmission rate pressure effects for each alternative relies on this data for the portion of historical retail rates attributable to transmission.

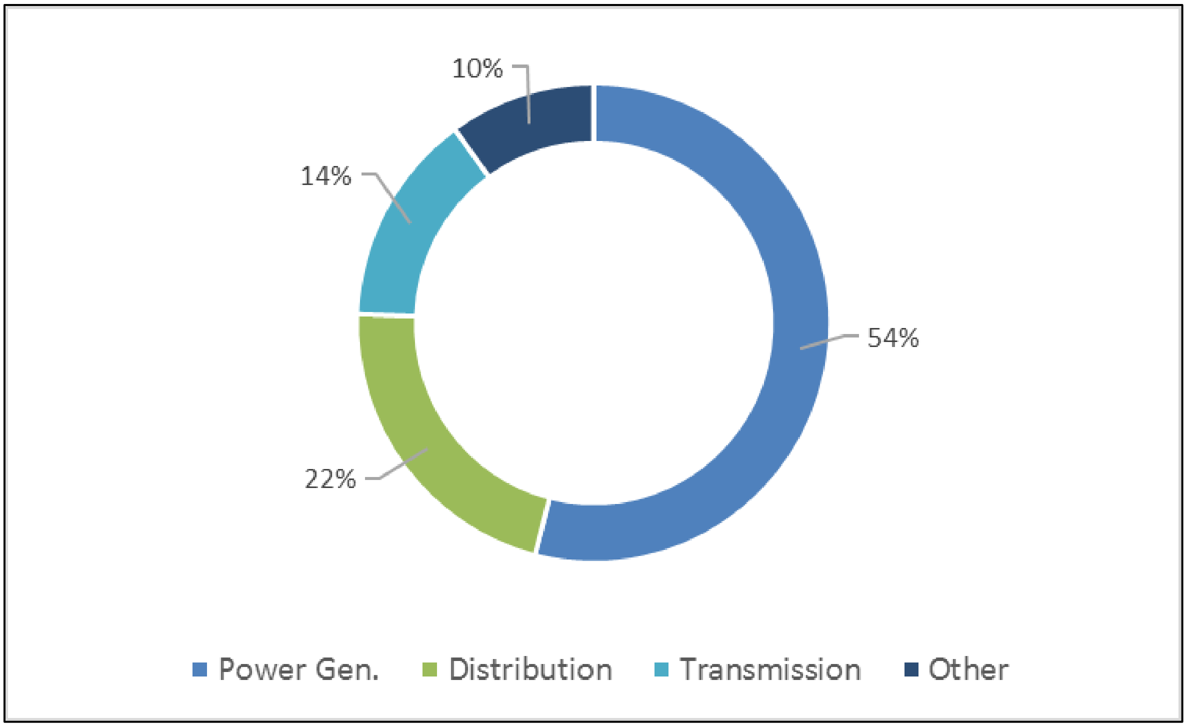


**Figure 3-176. Breakdown of an Average Retail Electricity Rate by Component**
Source: EIA (2016, 2019)

Table 3-124 presents the average retail rates across counties for residential, commercial, and industrial end users in the area of analysis under the No Action Alternative. The residential retail rate in counties across the Pacific Northwest, reflecting the full set of power customers across the Pacific Northwest, would range from 2.97 to 13.42 cents per kWh.

**Table 3-124. Weighted Average 2022 Estimated Retail Rates (cents per kWh), 2019 U.S. 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 |

## SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION

### Social Welfare Effects

As previously described, social welfare effects are estimated based on two methods: the market price method, which calculates changes in the market value of the changes in hydropower generation, and the production cost method, which quantifies the incremental costs of providing power under each alternative. As a baseline for these methods, average annual generation from Pacific Northwest hydropower under No Action is 13,000 aMW (equivalent to 120,000,000 MWh) under the base case.

### Regional Economic Effects

Table 3-125 summarizes the estimated average monthly consumption and bills by end user type under the No Action Alternative.

**Table 3-125. Average Consumption and Monthly Bills for Each End-User Group under the No 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 |

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

The retail rate forecast considers the NW Council's economic forecast for both growth in electricity rates for ratepayers over time, as described for residential end users in Table 3-126, and growth in load per household and for commercial and industrial end users. The No Action analysis relies on these forecasts to evaluate the socioeconomic effects over time.

### Residential Effects

Retail electricity rates would remain relatively low (some increases after 2028) and loads relatively flat (NW Council 2017, 2019). Table 3-126 presents the average forecasted residential retail rate from 2022 to 2040 (including 2022, and then in five-year increments from 2025).

**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 |

Figure 3-177 presents geographic effects of the rates and expenditures across Pacific Northwest counties in 2022. Darker shading represents higher average rates and expenditures as a percentage of income. Electricity rates for residential end users would be highest in areas of Montana with certain counties of Oregon and Washington experiencing higher rate than the regional average. Rates are typically higher in Montana than the other states in the region and, despite slightly lower consumption of electricity, the higher rates coupled with slightly lower median income levels result in higher-than-average spending on electricity, consistent with existing conditions (EIA 2018a; NW Council 2015).

The rates would be higher in rural counties not adjacent to metropolitan areas, where the average residential retail rate would be between 9.84 and 13.42 cents per kWh. In metropolitan areas with populations above 250,000 residents, average residential retail rates would be lower, ranging from 7.11 to 11.44 cents per kWh.

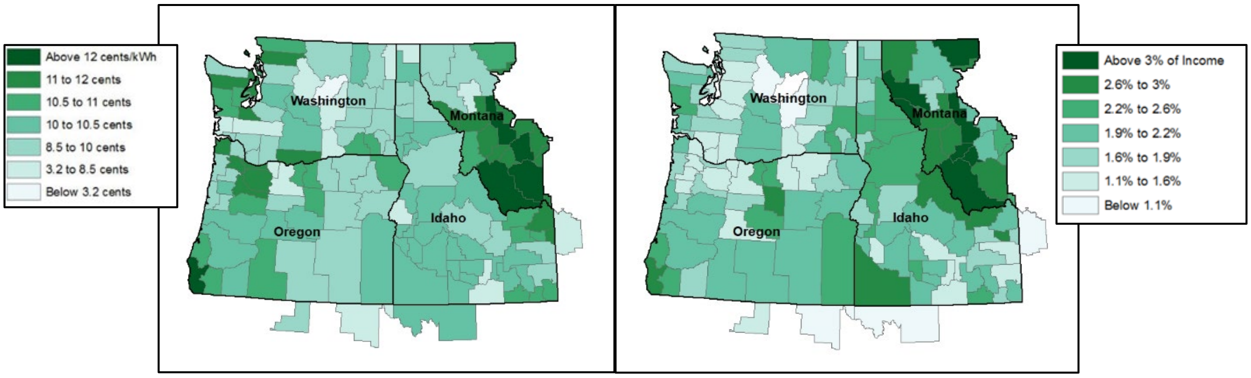


**Figure 3-177. Average Residential Retail Rates in Cents per kWh (left) and Percentage of Household Income Spent on Electricity (right).**

Over time, retail electricity rates would decrease in real terms (i.e., adjusted for inflation) while demand for electricity remains relatively flat (NW Council 2016, 2019). Table 3-127 lists the average annual household expenditures on electricity over a 20-year time period across the Pacific Northwest. The rates, and resulting household electricity expenditures, would decrease over time under the No Action Alternative until 2028 due to the rate decreases and relatively flat demand growth described in Table 3-126.

**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 |

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

Using median household income by county, this analysis estimates the percent of income spent on electricity per household (Table 3-128). The percentage of electricity, on average, would be 1.7 percent of median household income. This ratio fluctuates based on county income levels with lower income levels spending more on electricity. Figure 3-177 shows the geographic breakdown of the percentage of income spent on electricity by county. The highest percentage of expenditures occurs in a single county (Glacier County, Montana) with 4.1 percent. Over time, because income would increase more than the estimated retail rates, the portion of income spent on electricity would decrease over time for all load and rate growth rates. Given considerable uncertainty around future load and rate changes over time, the analysis considers three potential growth rates (high, medium and low).

**Table 3-128. Average Percent of Median Household Income Spent on Electricity (percent of 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% |

**Commercial and Industrial Effects**

Commercial and industrial end users also experience increasing rates over time under the No Action Alternative.[59] The retail rates would be on average 8.89 cents per kWh for commercial end users and 7.25 cents per kWh for industrial end users across the Pacific Northwest. As described in Table 3-124, these rates vary by county with higher and lower retail rates.

These end-user groups consume far more electricity than households every year, paying large monthly bills for electricity use, thus their usage under the No Action Alternative would reflect this. On average, commercial end users would pay $5,900 per year on electricity—a $500 monthly bill. Unlike residential load, industrial load would increase over time for the majority of industrial end users and some commercial end users (NW Council 2016). Consistent with NW Council forecasts, demand for electricity under the No Action Alternative would decrease in Idaho for industrial users while increasing in all other states. Similarly, Washington would experience decreases in load for commercial end users while all other states would experience small increases. By 2040, the average expenditures on electricity for commercial end users would decrease slightly to $5,400 annually ($450 monthly). Industrial end users average annual bills would remain relatively constant, from $48,000 to $50,000 by 2040, with increasing load but decreasing rates.

Table 3-129 presents the forecast of average annual expenditures on electricity for commercial and industrial consumers.

**Table 3-129. Annual Expenditures for Commercial and Industrial End Users under the No 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) |

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.

For industrial end users, the NW Council forecasts the total revenue generated by that sector—in 2022, it would be $140 billion. Total industrial expenditures on electricity would be $5.1 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.

#### Other Social Effects

Some households use more electricity and thus spend more relative to others. There is the potential for households to experience energy insecurity (e.g., inability to use heating or cooling equipment or reducing food or medicine to pay for energy costs) should electricity rates increase (EIA 2018a). Additionally, health and safety concerns may arise during blackouts when certain services are not available (operation of medical devices or safety equipment). Under the No Action Alternative, expenditures on residential electricity are consistent with recent trends that would be unlikely to create conditions for energy insecurity. Expected income growth and low load growth indicates that expenditures on energy as a percent of income, in fact, decrease over time (EIA 2018a; NW Council 2019). Similar to rates, power and transmission system reliability under the No Action Alternative is similar to current trends and would not increase the frequency of outage events so no health and safety effects would be expected.

### SUMMARY OF EFFECTS

The generation of the CRS projects and the Federal system would remain similar to recent history. Wholesale power and transmission rates would continue to increase slowly over time. Combined with increasing median household incomes and relatively slow load growth, spending on electricity as a percentage of income would decrease over time.

In the scenarios with limited or no coal generation in the future, the CRSO EIS analysis assumes that regional entities would acquire additional resources to replace the coal-based generation to maintain power system reliability. If these resources are not acquired, then the region would experience substantial reliability risks. These scenarios provide an approximation of effects based on current information. The decision whether or not resources are built, what type of resources are built, and when resources are built influence the analysis of effects of the MOs relative to the No Action Alternative, so certain assumptions were made to estimate these potential effects. If a Federal decision was made that substantially affected reliability, additional NEPA analysis would likely be needed to determine how to address these effects (Table 3-130).

**Table 3-130. Summary of Effects under the No Action Alternative without Additional Coal 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.

### *3.7.3.3 Multiple Objective Alternative 1*

This section evaluates effects under MO1. Overall, hydropower would decrease relative to the No Action Alternative under MO1; therefore, the analysis accounts for potential replacement resources that would maintain LOLP at No Action Alternative levels. The effects of decreased hydropower generation and the need for replacement resources would result in slight upward rate pressure under MO1 relative to the No Action Alternative.

**CHANGES IN POWER GENERATION**

Table 3-131 and Figure 3-178 present the generation for No Action and MO1 and their differences by month. Overall, generation from the CRS projects would drop from 8,300 aMW under the No Action alternative, on average, over all water years, to 8,200 aMW under MO1. This represents a decrease of 130 aMW, [61] which is a 1.6 percent decrease in generation on average. The reduction in critical water generation from MO1 is even greater. (The decrease in generation from all Northwest U.S. projects including the non-Federal projects that are affected by changes in the CRS projects is -170 aMW.) The critical water year generation of the CRS projects would decrease by 5 percent (300 aMW), and the amount of firm power used to supply Bonneville's long-term contracts would decrease by 300 aMW.

**Table 3-131. Monthly Electricity Generation at the Columbia River System Projects under 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%** |

Notes: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding. HYDSIM modeling inadvertently omitted the impact of the *Winter System FRM Space* in December of some years, which would move some generation (0 to 450 MW depending on the year) from January into December. This 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.

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.
Source: HYDSIM modeling results

The three measures that appear to have the largest impact on generation are the *Lake Roosevelt Additional Water Supply*, *Block Spill Test (Base + 120/115%)*, and *Modified Dworshak Summer Draft*. The additional water supply reduces generation throughout the spring and summer. The MO1 spill regime decreased generation in the spring as spill was increased compared to No Action. The changes in flow at Dworshak increased June, July, and September generation but caused a large reduction. The reduction in August generation in MO1 is substantial enough to lead to loss-of-load events in August, particularly in the first half of the month before summer spill ends. In the No Action Alternative, generation in August is sufficient to ensure that there are few substantial loss-of-load events.

While the change in generation would not be large on average across the year, the effect on LOLP would be larger due to the timing within the year of when the generation decreases are forecast to occur. Modeling results showed that generation would primarily decrease in December (largely due to the change in end-of-December elevation at Libby), the spring (largely due to increases in spill), and late summer (largely due to the change in timing of flows from Dworshak and increases in irrigation). There would be increases in January and February (from Libby starting January at a higher elevation). Because late summer and winter carry the highest probability of generation insufficiency, the relatively larger decreases in generation in August and December would have a greater impact on LOLP than might otherwise be expected given the annual average reduction in CRS generation is limited to 130 aMW and generation on the Northwest U.S. system including non-Federal projects decreases by 170 aMW.

The ability of CRS projects to meet peak- and heavy-load periods would decrease by 1 percent and 4 percent, respectively, relative to the No Action Alternative. Based on a qualitative assessment of the alternative, some measures in MO1 would slightly increase the flexibility of operating the CRS projects while other measures would slightly decrease the flexibility affecting the ability to integrate other renewable resources into the power grid.

Other non-Federal regional hydropower projects that are located downstream of CRS projects (such as the Mid-Columbia hydro projects) would experience similar trends as the CRS projects in the winter from flow changes upstream of these projects. However, the projects would not be affected by the changes in fish passage spill in MO1 or flow changes at Dworshak in late summer. The regional generation including these non-Federal projects would be on average 13,000 aMW, which is a decrease of approximately 1 percent (170 aMW) relative to the No Action Alternative (at 13,000 aMW). The CRS projects account for 130 aMW of the 170 aMW decrease under MO1.

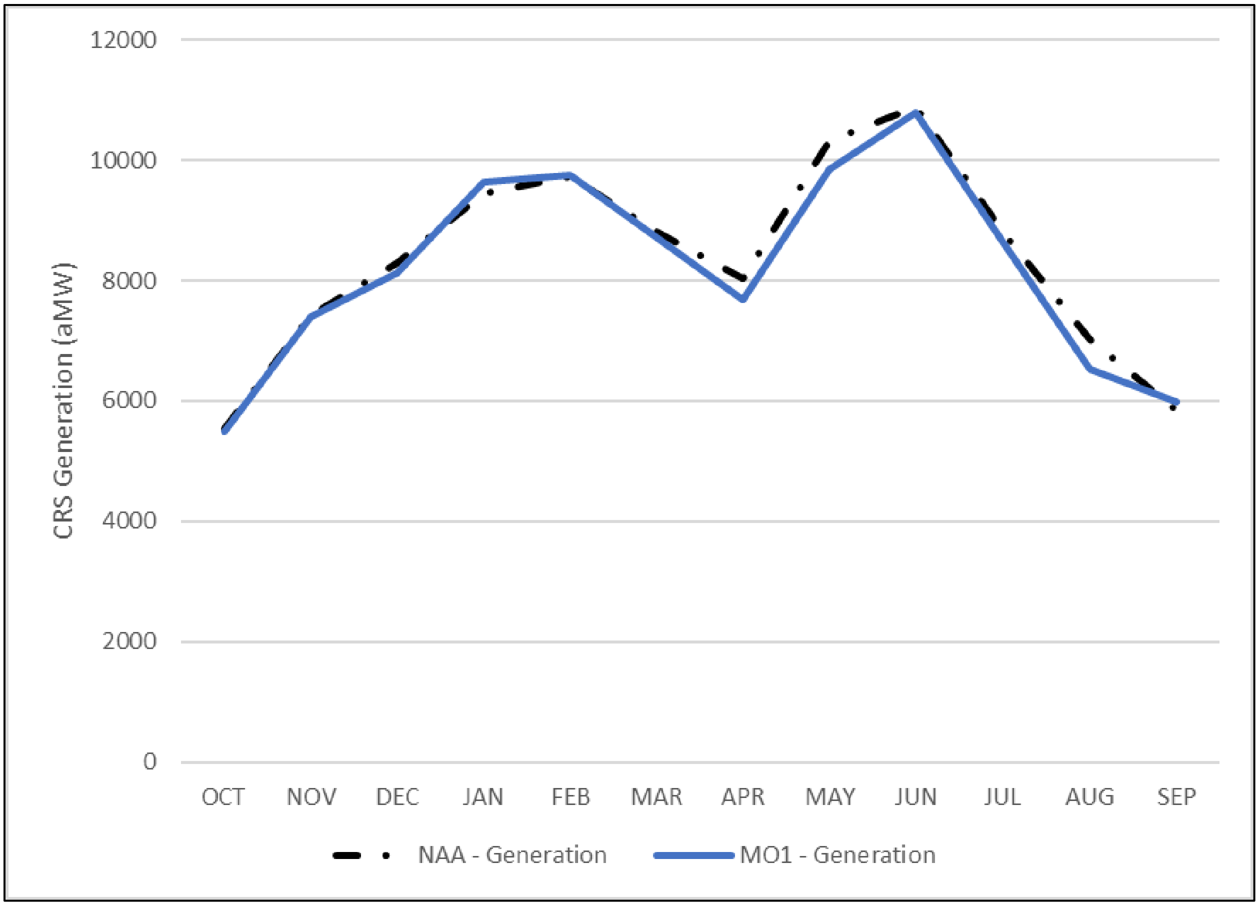


**Figure 3-178. Monthly Hydropower Generation at the CRS Projects, No Action Alternative and Multiple Objective 1, in aMW, for the Base Case without Additional Coal Plant Retirements**

**EFFECTS ON POWER SYSTEM RELIABILITY**

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.

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

No Action Alternative and for MO1. However, the increase will not be the same for the two alternatives. Regional utilities and Bonneville trade power with each other (hourly, daily, monthly and longer) depending on when a utility is surplus or deficit because of seasonal and shorter variations in demand for power and variations in supply (e.g. water availability impacting hydropower generation). As operations and power generation change between the No Action Alternative and MO1, the seasonality of when Bonneville may rely on generation from non-federal sources to meet load will change. Thus, when coal-plants are retired, their impact on reliability would be different depending on the seasonality of generation losses in the No Action alternative versus that of MO1. LOLP is not linear in part due to the complex seasonally varying interactions between generation and load in the region. In future scenarios with limited coal capacity, the LOLP under MO1 would increase by 12 percentage points compared to the No Action Alternative. In other words, this would result in absolute LOLP percentage values of 39 percent in a limited coal capacity scenario (whereas No Action is 27 percent). The non-linearity of LOLP manifests itself further in the no-coal scenario; the LOLP under MO1 would be 6 percentage points higher than the LOLP of the No Action Alternative, with an absolute LOLP of69 percent without any regional coal capacity (whereas No Action is 63 percent) . Table 3-132 summarizes these LOLP values.

**Table 3-132. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 1 Relative to the No 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 |

Notes: The replacement resources for the No Action Alternative include demand-response, wind, and solar; for MO1 the analysis additionally includes storage (e.g., batteries, pumped storage). The incremental resource builds under the more limited coal capacity or no coal capacity scenarios are additive with the resource builds under the base case, so the total effect is 1,800 MW of build in all three scenarios.

**POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

To maintain power system reliability in the Northwest, additional generation resources and transmission facilities would be needed under MO1. However, construction of new resources (e.g., gas, solar, wind, or pumped storage) and new transmission can easily take a decade to bring online given the time needed for planning, permitting, land acquisition, and physical construction. Setting aside the timing of construction, under the least-cost replacement generation portfolio, returning LOLP to the No Action Alternative level would require about 560 MW of single-cycle natural gas turbines.[62] (The transmission analysis assumes these would be located in the northeastern Oregon area, which would optimize accessibility to gas pipeline and transmission capacity.) This portfolio would cost $27 million annually, including annualized capital costs, fixed operations and maintenance, and insurance (2019 dollars). This figure does not include the annual cost of fuel to generate power, nor variable operation and maintenance costs, which would vary depending on annual power production. During critical water conditions, the fuel cost plus variable costs would be roughly $16 million annually (2019 dollars). The decision on the exact resources to be built in the region would ultimately be made incrementally by various regional parties. The Socioeconomic section below examines the rate effects of various options depending on whether Bonneville or other entities take the lead in developing and acquiring the needed resources. It also addresses the fact that different customers are affected differently depending on these financing options and by what utility provides their power.

Under the zero-carbon resource portfolio, about 1,200 MW of solar power in central Oregon and 600 MW of demand response would reduce MO1's LOLP to the No Action Alternative level. (The transmission analysis assumed solar would be located in central Oregon based on proposed projects in the interconnection queue as well as the location's high solar output.) Solar power would be more effective in reducing LOLP and lowering costs than wind energy because in MO1 the largest increases in LOLP relative to No Action Alternative occur from June through August when solar resources generate the most power. A 1,200 MW build out of solar power would require roughly 7,000 acres of land in central Oregon or approximately 11 square miles. Such a large buildout of solar capacity would likely result in additional, but currently unknown, impacts to environmental and cultural resources, which may include vegetation, wildlife habitat, archeological resources, and traditional cultural properties. Additional environmental and cultural impacts from resource replacement would be identified and analyzed by appropriate parties during future site-specific environmental review, including 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.

the solar power and $29 million per year for the demand response (2019 dollars).[63] The analysis does not include the additional generation balancing reserves needed to integrate renewable resources into the power grid.

As discussed above, the LOLP impact on the No Action Alternative and MO1 from the retirement of coal plants is non-linear. Furthermore, how the coal resources are replaced (by the owners of the coal resources) affects when a utility might have more or less surplus. Specifically, if new solar resources are a large portion of the coal-plant replacements, then these utilities may have more surplus in the summer when solar power generation is most efficient. Because the seasonal pattern of generation is different in the No Action Alternative compared to MO1, the replacement resources for coal will affect the need for replacement resources for the hydropower generation loss in MO1. Because of this effect, the need for replacement resources in NAA increases more with limited coal-plant retirements and the no-coal scenario than it does for MO1. Thus, if Bonneville (or the region) acquired 1,800 MW to return MO1 to a NAA LOLP of 6.6 percent for the base case, there would be no additional needs to acquire resources in the limited-coal case or the no-coal scenario  for MO1 than it would have otherwise acquired under the No Action Alternative.

**BONNEVILLE FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION PLAN COSTS**

Operational measures are similar to those analyzed under the No Action Alternative; therefore, fish and wildlife mitigation costs are estimated to be similar to those established under the No Action Alternative, and the summary rate table for the Base Case analysis includes an estimate of approximately $339 million in annual costs for Bonneville Fish and Wildlife Program and LSRCP combined for MO1. In 2016, the Bonneville Fish and Wildlife Program spending level was $267 million and the LSRCP spending level was $32 million (BP-16 Rate Case). Adjusted to 2019 dollars, these are $281 million and $34 million, respectively.

**EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

**Bonneville Interconnections**

The developer of the individual replacement resources would have to develop additional transmission infrastructure, such as interconnection lines, which would result in additional costs—attributed to the cost of developing the actual resource—to reach the larger transmission network. Those costs would vary depending on the geographical location of the resource with respect to the transmission network, size of the individual project, and other factors.

Bonneville, for its part of the resource interconnection, would provide additional network 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.

new resource to the larger transmission network. The Bonneville interconnection would require equipment such as bulk transformers, circuit breakers, and other substation equipment that may require the expansion of substations beyond their existing footprints. Transmission substation interconnection infrastructure like this can take several years to plan, permit, and construct, especially if the substation requires expansion beyond its current footprint.

Based on the assumptions described above, Bonneville identified approximately $70 million in direct costs on the transmission network (which customers would fund, and Bonneville would repay in transmission credits) necessary to accommodate the interconnection for the least-cost portfolio under MO1. Bonneville identified $72 million in direct costs on the transmission network necessary to accommodate the interconnection for the zero-carbon portfolio under MO1. These costs would be between $3.8 million and $3.9 million when annualized.

The analysis did not identify any additional Bonneville transmission infrastructure needs or transmission system reliability issues associated with the interconnections under MO1 beyond the facilities and costs described here.

**Bonneville Transmission System Reliability and Operations**

Changes in hydropower generation combined with replacement generation from the two replacement resource portfolios would likely not result in any transmission system reliability issues requiring transmission reliability projects beyond what has been identified in Bonneville's regular system assessments. Due to expected increases in loads in the Tri-Cities load service area, Bonneville's regular system assessments have identified several transmission reliability projects that are anticipated to occur within and beyond the 10-year planning horizon.

Because MO1 provides for reduced generation capability, there would also be a reduction in the number of generating units online at a given time at the CRS projects of the lower Snake and lower Columbia Rivers. With a reduced number of operating units and uncertainty about the characteristics of replacement resources, there may be a reduced capability to provide voltage support and dynamic stability in response to significant disturbances throughout the Western Interconnection. This could result in reduced operating limits to avoid equipment damage and potential uncontrolled load loss. However, the assumed operating limits were not changed because there is not enough certainty about the possible replacement resources to have confidence that changing the limit assumptions would increase accuracy when the studies were performed.

Operating at lower operating limits could result in increased congestion and result in redispatch of resources throughout the Western Interconnection to meet the required load demands at that time beyond that reported below under the Regional Transmission System Congestion Effects subsection. The effect on operating limits would vary based on the capability of resources online at the time and the location of those resources.

Because coal and gas generation have similar characteristics to hydropower,[64] there may be issues with voltage and dynamic stability in scenarios with limited or zero coal and gas generation in the region. Renewable resources, such as solar generating facilities, currently have neither the technology nor the requirement to provide comparable dynamic and frequency support.

Technology under development and implementation of additional requirements may be needed under a zero-carbon resource portfolio in order to have certainty that replacement solar resources will be able to provide adequate reactive and dynamic support to respond to larger transmission disturbances.[65] It could take several years to design, permit, and construct these additional transmission reinforcements should they be needed.

**Regional Transmission System Congestion Effects**

During high runoff conditions when more hydropower is generated, the number of congestion hours in the west-to-east flow direction would be greatest along the Hemingway-Summer Lake transmission path, which would experience higher congestion hours (up to 214 additional hours) compared to No Action. Other west-to-east flow paths would experience modest (less than 50 hours) shifts in the number of hours of congestion. During times of transmission path congestion, the transmission of power generated in the west would be limited and loads would need to be served by higher cost generating resources east of the congested path, which would result in higher costs to serve the load during those times.

With the exception of the Pacific DC Intertie, the north-to-south paths would have modest changes in congestion hours. The congestion on the Pacific DC Intertie in the north-to-south flow direction would increase up to 71 hours, depending on hydro runoff conditions and the replacement resource portfolio. If the assumed replacement resources were not in place when the changes in hydropower generation were implemented under this alternative, the number of hours and location of congestion would change depending on which replacement resources were online.

Under limited or no-coal scenarios, the congestion effects of CRS hydropower reductions with or without replacement resources could be amplified above what is reported above.

Detailed graphs depicting the number of hours of congestion along the individual paths under different water years appear in Appendix H.

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[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.

Overall, changes in the patterns of CRS generation under MO1 and its replacement resource portfolios would have a relatively small or minor impact on congestion for Pacific Northwest transmission paths.

**ELECTRICITY RATE PRESSURE**

**Bonneville Wholesale Power Rates**

Under MO1, assuming that the region acquires the necessary replacement resources, Bonneville's wholesale power rate would experience upward rate pressure for all portfolios in MO1 relative to the No Action Alternative, with the greatest upward rate pressure related to the zero-carbon portfolio. Bonneville or other entities not be able to offset the additional costs identified in MO1 the upward rate pressure would lead to rate increases. Average Bonneville Wholesale Power Rate **u**nder Multiple Objective 1. Line 1 presents the estimated wholesale power rate based on changes in the amount of hydropower generated and the surplus (market) sales for the base case without additional coal plant retirements. These rate estimates also include annualized structural cost measures, which total $20.7 million (2019 dollars) under MO1. Appendix H, *Power and Transmission*, presents detailed information on structural measure costs and the effects on wholesale power rates.

On average, upward rate pressure may result in increases in Bonneville's wholesale power rates of $2.08 per MWh to $2.97 per MWh depending on the replacement portfolio and financing portfolio (2019 dollars). This would represent a 6.0 to 8.6 percent increase in the average Bonneville wholesale power rate compared to the No Action Alternative.

Summary results for Bonneville's wholesale power rate pressure analysis in the Bonneville Finances scenario are presented in the first section of Table 3-133. As discussed in Section 3.7.3.1, the second section of Table 3-133 provides the cost pressure to the region of MO1 in light of potential carbon compliance and accelerated coal retirements. Results for the Region Finances scenario are presented following this discussion. The summary analysis focuses on the Bonneville Finances scenario because this includes most of the relevant costs affecting Bonneville's customer base, while the Region Finances scenario excludes real costs affecting regional rates that are not explicitly included in Bonneville's wholesale rate.

### *Bonneville Finances*

**Table 3-133. Average Bonneville Wholesale Power Rate ($/MWh) Under Multiple Objective 1, for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures 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 | |

Note: Line 14 represents the approximate range in fixed costs for replacement resources for the more limited coal scenario and the no coal scenario. Additional changes in value, denoted by line 15, would occur from changes in market prices, changes in technology, and many other factors. Because the retirement of coal plants in the region will change the utility landscape far from the current condition, there is not enough information available to extrapolate from today's information. Base rate includes Colville Settlement Payment, which has a 0 to 1 percent increase from No Action Alternative.

Base Case Analysis

In the Bonneville Finance Scenario, base rate pressures range from 6.0 percent to 8.6 percent depending on the resource portfolio, with a higher rate pressure associated with the zero-carbon resource replacement. In the zero-carbon scenario, annual average cost pressure from changes due to costs is $172 million per year (2019 dollars) which equates to a 8.4% upward pressure on rates, coupled with a small increase in preference customer loads resulting in a 0.2% upward pressure on power rates, resulting in an overall change to base rates of 8.6%. Rate pressure includes a reduction in net secondary revenues, increased capital costs to finance and maintain the solar resource replacement, structural measure debt financing, and higher energy efficiency expenses associated with the demand response program. In the conventional least-cost scenario, the $80 million per year (2019 dollars) in upward rate pressure which equates to a 4.0% upward rate pressures, is associated with lower net secondary revenues, and capital, fuel and O&M costs associated with the gas turbine resource replacement, as well as structural measure debt financing. In addition to these cost pressures, loads in the conventional least-cost scenario are lower, contributing alone to a 2.0 percent upward pressure on power rates. Overall, the base rate pressure is 6.0%.

<u>Rate Sensitivity Analysis</u>

Rate sensitivities are presented in Table 3-133, lines 5 through 11, to provide quantitative estimates relative to additional sensitivity analyses described in Section 3.7.3.1. No sensitivity is provided for the Bonneville Fish and Wildlife programmatic expenses (line 5) because the cost analysis identified equivalent spending with the No Action Alternative.

For Integration Services (line 6), other than energy shaping effects between heavy load hours[66] (HLH) and light load hours[67] (LLH) periods, changes in the value of lost flexibility due to increased spill and other constraints on the CRS under MO1 are not explicitly included in base rates. Generation inputs revenues for contingency reserves and balancing services are assumed to be the same as the No Action Alternative. However, the ability of the CRS to carry generation balancing reserves is reduced under MO1. To monetize the value of changes in contingency and generation balancing reserve carrying capability, the sensitivity analysis incorporates integration costs associated with contingency and balancing needs of replacement resources.

Annual resource integration costs associated with replacement resources under MO1 were calculated using BP-20 operating and generation balancing reserve rates. Estimated annual integration costs for the 1200 MW solar resource replacement under MO1 for the zero carbon portfolio ranged from $29 million to $34 million.

Resource replacement financing (line 7), which addresses alternative amortization periods to the 30 years assumed in base rates, shows upward cost pressure of $30 million per year in the zero-carbon portfolio and $6 million per year in the conventional least-cost scenario. Resource cost uncertainties (line 8) range from a $6 million per year upward rate cost pressure to a $6 million per year downward rate cost pressure in the zero-carbon scenario, and $3 million per year in the conventional least-cost scenario. Demand response costs (line 9) could be lower than assumed in the $20 million/year in base rates; a potential cost savings of 12 million per year is shown on the low end for this sensitivity. However, to account for the challenges to 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.

resource portfolio could be as high as $52 million per year higher than assumed in base rates if up to 50 percent of the program needed to be replaced with a 300 MW solar resources with battery technology instead. OMP costs associated with oversupply events could be $3 to $4 million per year higher in the zero-carbon scenario, and $1 million higher in the conventional least-cost scenario.

<u>Other Regional Cost Pressure</u>

Line 13 provides an estimate of the incremental carbon compliance costs associated with MO1. Effects associated with regional carbon compliance laws are unknown, pending current legislation in Oregon and Washington as discussed in Section 3.7.3.1. If binding estimates effective in the future are enforced to the resource portfolio in MO1, regional utilities could face cost savings relative to the No Action Alternative of as much as $16 million per year, or cost pressures as much as $88 million per year in the zero-carbon scenario. In the conventional least-cost scenario, carbon enforcement costs could range between $11 million and $57 million per year.

As described in Sections 3.8.3.1, Availability of Coal Resources subsection, and 3.8.3.2, Effects on Power System Reliability subsection, regional utilities would need to add 8,800 MW of additional zero-carbon resources in the limited coal capacity scenario and 28,000 MW of additional zero-carbon resources in the no coal capacity scenario to maintain regional LOLP at No Action Alternative levels (6.6 percent). ). See Table 3-133. Lines 14 and 15 estimate the incremental zero-carbon resources costs needed by the region to maintain the No Action Alternative LOLP of at least 6.6 percent under MO1 in light of a limited or no coal assumption. An "incremental zero-carbon resource cost" occurs if the combination of (1) the resources Bonneville or the region is expected to acquire under MO1, plus (2) 8,800 MW (under the limited coal scenario) or 28,000 MW (under the no coal scenario), is less than the total amount of zero-carbon resources needed to return the region to the No Action Alternative LOLP of 6.6 percent under the applicable coal scenario.

For the limited coal capacity scenario under MO1, a minimum of 9,300 MW of zero-carbon resources would need to be added to maintain regional LOLP at the No Action Alternative level of 6.6 percent. See Table 3-132. Bonneville or the region is expected to acquire 1,800 MW of zero-carbon resources under MO1 in the base case analysis. Adding 1,800 MW to 8,800 MW exceeds the minimum 9,300 MW, so this MO has no incremental cost impact on the region if a limited coal scenario is assumed.

For the no coal capacity scenario under MO1, a minimum of 27,000 MW of zero-carbon resources would be needed to maintain regional LOLP at the No Action Alternative level of 6.6 percent. See Table 3-132. Because this number is already below 28,000 MW (the amount of zero-carbon resources needed under the No Action Alternative in the no coal scenario), this MO has no incremental cost impact on the region if a no coal scenario is assumed.

***Region Finances***

Results for the region finances scenario are presented in Table 3-134. It is important to note the rate pressures in this table are from the perspective of Bonneville's wholesale power rates. In the region finances scenario, replacement resource costs are excluded from Bonneville's wholesale rate, with those costs collected from rates charged by other entities in the region, ultimately paid by the customers of utilities that would be receiving less power from Bonneville. The Socioeconomic section below shows the geographic distribution of rate pressure down to retail rates in both scenarios, so that the costs that are not in Bonneville rates in the region finances scenario are included in retail rate impacts of the consortium of public customers assumed to finance the resource replacement.

**Table 3-134. Average Bonneville Wholesale Power Rate ($/MWh) Under Multiple Objective 1, for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures 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%** |

**Market Prices**

The surplus market sales vary depending on the replacement resource while the amount of surplus power would increase for all portfolios. In order to meet power system reliability needs at all times, enough solar had to be added to meet periods of highest demand, the peaks in the winter, leading to periods of surplus at other times, such as in the summer. The average market price also experiences upward price pressure, potentially leading to increases in price to $19.63 per MWh under the conventional least-cost portfolio, and downward price pressure, potentially leading to decreases in price to $19.18 per MWh under the zero-carbon portfolio. These effects would be changes of +1.1 percent and -1.2 percent relative to the No Action Alternative price of $19.42 per MWh. Figure 3-179 shows the average market price and average CRS hydropower generation by month under the least-cost portfolio. Relative to the No Action Alternative, average prices decline by $1.0 per MWh in September when generation is relatively high.

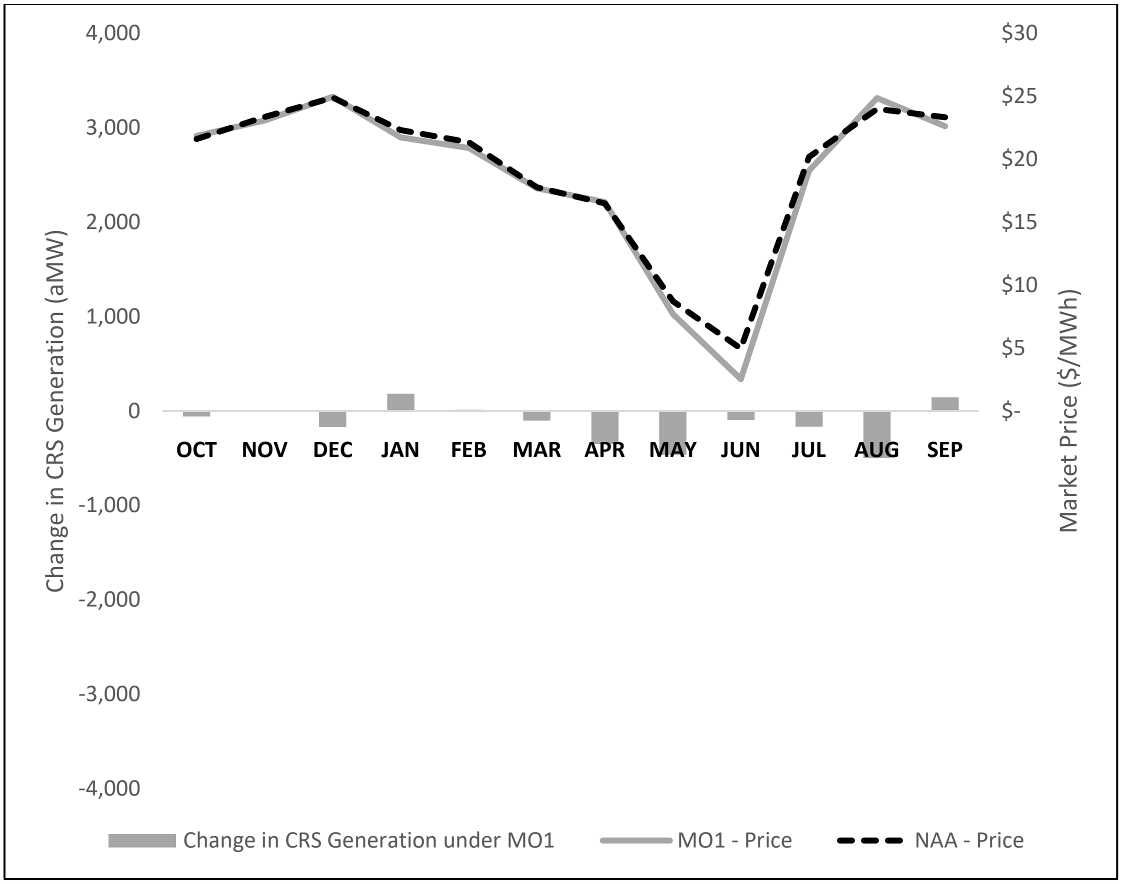


**Figure 3-179. Monthly CRS Generation (aMW) and Market Price ($/MWh).**

Note: The right axis is the market price ($/MWh). The left axis is generation from the CRS projects by month (aMW).

Source: Power Analysis.

### Bonneville Wholesale Transmission Rate Pressure

Under MO1, the Bonneville wholesale transmission rate pressure would increase for both portfolios relative to the No Action Alternative, with the highest increases related to the least-cost replacement portfolio. The upward transmission rate pressure would be 0.74 percent annualized (6.1 percent over an 8-year period) under the least-cost replacement portfolio and 0.62 percent annualized (5.1 percent over an 8-year period) under the zero-carbon replacement portfolio. Changes in capital costs, and long- and short-term sales, contribute to this upward rate pressure. Although the capital costs associated with interconnecting the zero-carbon replacement portfolio would be greater than the least-cost portfolio under MO1, the potential for additional long-term sales associated with the amount of solar power generation under the zero-carbon portfolio would likely result in lower overall transmission rate pressure. The short-term sales associated with the zero-carbon replacement portfolio would also increase, reflecting the changes to hydropower generation and associated market pricing (see described above). Across customers and portfolios, the range of annualized increases is 0.28 to 1.55 percent.

#### Retail Rate Effects

The retail rate that end users pay to their individual utilities for electricity would experience slight upward rate pressure under MO1 compared to the No Action Alternative. Should the upward rate pressure lead to increases in rates, the average retail rates under MO1 could range from 10.27 cents per kWh to 10.28 cents per kWh depending the replacement resource portfolio for residential end users. Retail rate pressures differ depending on how replacement resources are financed and whether the retail customer is receiving power from a utility supplied by Bonneville or whether the utility has different sources of generation. The rate pressures across portfolios would also be similar for commercial and industrial end users. These retail rates are 0.74 percent higher for the zero-carbon portfolio and 0.62 percent higher for the least-cost portfolio relative to the No Action Alternative.

### BONNEVILLE FINANCIAL ANALYSIS

As previously described, the Bonneville financial analysis considers the effects of the MOs on future cash flows over a 30-year financing period for potential replacement resources. For MO1, the discounted NPV of the cash flow effects under each resource replacement portfolio are described in Table 3-135 below. This NPV analysis is Bonneville specific and does not capture wider societal impacts. This NPV analysis uses a risk adjusted discount rate of 7.9 percent and a 30-year timeframe. The sensitivities in this analysis are described in the Power Rates Table 3-133.

**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** |

### SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION

Except where noted, this section describes the base analysis for MO1 without considering the range of additional costs shown in Table 3-133, and without the retirement of additional coal-plants.

#### Social Welfare Effects

This social welfare analysis employs both the market price and production cost methods based on the base case for this analysis, assuming no additional coal plant retirements. As described in further detail in Section 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*, the market price method estimates the societal loss or gain from changes in hydropower generation, valued at the monthly market price while the production cost method estimates the fixed and variable costs, both power resources and transmission, associated with providing power. These two approaches are not additive and present a national perspective without considering specific populations or regions, as discussed in the *Regional Economic Effects* section, below.

Table 3-136 presents the market value of the reduction in Pacific Northwest hydropower generation under MO1 as compared with the No Action Alternative. Based on the market price method, the average annual economic effect of MO1 is a $25 million cost. As previously described, there is considerable uncertainty regarding how the social welfare effects may change over the 50-year timeframe of the analysis. For example, regulatory and policy changes, technology, and the cost of technology change over time, influencing this value. However, if the average annual effects of $25 million persist over a 50-year timeframe (2022-2071), the net present value would be $680 million.[68]

**Table 3-136. Average Annual Social Welfare Effect of Multiple Objective 1 Based on the 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** |

Note: Changes in hydropower generation and the social welfare value are rounded to two significant digits. The weighted average market price is calculated based on average generation and prices across 14 time periods over the course of a year. Additional detail on this analysis is provided in Chapter 5 of Appendix H.

Table 3-137 evaluates the social welfare effects of MO1 based on the additional costs of adding enough capacity to the system to meet power demand given the reduction in hydropower generation described in Table 3-131, Monthly Electricity Generation at the Columbia River System Projects under Multiple Objective 1. That is, the social welfare effects quantified based on the production cost method are the marginal costs of providing power to maintain power system reliability. Based on this approach, the social welfare effects of MO1 range from an average annual cost of $64 million (assuming a least-cost replacement resource portfolio) to $170 million (assuming a zero-carbon replacement resource portfolio). Under the zero-carbon replacement resource portfolio, MO1 results in a net reduction in variable costs. This is because the variable costs account for changes in the cost of fuel for fossil fuel power plants, which is reduced relative to the No Action Alternative assuming the zero-carbon replacement resource portfolio. Even under the zero-carbon replacement resource portfolio, MO1 results in a net increase in variable costs. This is because the variable costs account for changes in the cost of fuel and other variable costs for fossil fuel power plants across the Western Interconnection, which increases relative to the No Action Alternative assuming the zero-carbon replacement resource portfolio. If these social welfare effects persist over a 50-year timeframe, the present 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.

**Table 3-137. Average Annual Social Welfare Effect of Multiple Objective 1 Based on the Increased Cost of Producing Power to Meet Demand (2019 U.S. Dollars)**

| | Replacement Resource Portfolio | |
|---|---|---|
| **Production Cost Factor[1/]** | **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 |

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
1/ Negative values in the table represent an increase (net cost) in the cost of producing power.

### Regional Economic Effects

Estimated average retail electricity rates would experience upward rate pressure under MO1 by roughly a tenth of a cent per kWh for the zero-carbon portfolio and slightly less under the least-cost portfolio relative to the No Action Alternative. These upward retail rate pressures may increase average electricity expenditures by 0.62 to 0.74 percent, depending on the portfolio, for electricity consumers across the region relative to the No Action Alternative.

### Residential Effects

Examining potential upward retail rate pressure on a geographic basis, the effects of MO1 would affect residential end users across the Pacific Northwest. The majority of households in the region (between 73 and 85 percent) would experience an upward rate pressure of 0 to 1 percent under the least-cost resource portfolio. One percent of households would experience upward rate pressure of greater than 5 percent under the zero-carbon portfolio and one quarter of regional households would experience downward rate pressure. The downward rate pressure is primarily due to reduced market prices and variable costs compared to the No Action Alternative. Households served by utilities receiving power from Bonneville would experience larger increases in rate pressure than households served by utilities not receiving power from Bonneville.

While rates remain highest in rural areas, the upward retail rate pressure would occur across the entire region. Large metropolitan urban areas would experience the smallest upward rate pressure relative to the No Action Alternative. Urban areas that are not adjacent to metro areas would experience the largest upward rate pressure, ranging from 0.60 to 1.4 percent. By CRSO region, rate effects would be concentrated in Region D with average increases in rate pressure ranging from 1.0 to 1.7 percent. Region A would also experience relatively high average increases in rate pressure ranging from 0.64 to 1.1 percent. Table 3-138 summarizes the rate effects by CRSO region.

**Table 3-138. Average Residential Rate Pressure Effects by Region with Percentage Change of 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% |

Figure 3-180 maps potential residential retail rate pressure effects by county for MO1. In general, upward rate pressure could be 0.62 to 0.74 percent, with only 1 percent of households experiencing rate pressure over 5 percent (under the zero-carbon Region-financed portfolio). Under the Bonneville-financed portfolio with a zero-carbon portfolio, 24 counties across the region would experience upward rate pressure greater than 2.5 percent relative to the No Action Alternative. These counties are largely non-metropolitan areas that represent 5.6 percent of households in the Pacific Northwest region.

Over time, upward rate pressure would increase faster under MO1 relative to the No Action Alternative (Table 3-139). This is due to the rate pressure that increases retail rates slightly over the period of analysis. By 2041, the difference in residential retail rates would increase from 0.67 in 2022 to 1.2.

To the extent that the upward rate pressure leads to changes in rates, end users would increase spending on electricity. The average increase in expenditures under MO1 relative to the No Action Alternative would range from 0.53 to 0.74 percent, depending on the portfolio. By 2041 the difference in rates grows under the different portfolios due to the increasing rate pressures. In 2041, the average increase in monthly bills ranges from $0.50 to $0.80 per month relative to the No Action Alternative. Table 3-140 presents the portion of regional households that experience a range of changes in expenditures.

Residential consumers in some counties would experience changes ranging from small reductions to up to $64 increases in their annual electricity spending compared to No Action in 2022. In the Bonneville-financed scenario, the average increase in annual electricity spending is $7 per year for both the zero-carbon and least-cost resource portfolios. As a percentage of income in counties, the average effects of MO1 relative to No Action are minimal with changes of 0.01 percent of annual income on average. The average percent of median income spending on power would increase from 1.69 percent under the No Action Alternative to 1.7 percent under MO1. The largest increase would be a 0.1 percent increase in the percentage of income spent on electricity. The total increase in household spending on electricity across all Pacific Northwest households is between $35 million and $41 million per year depending on the replacement resource portfolio.

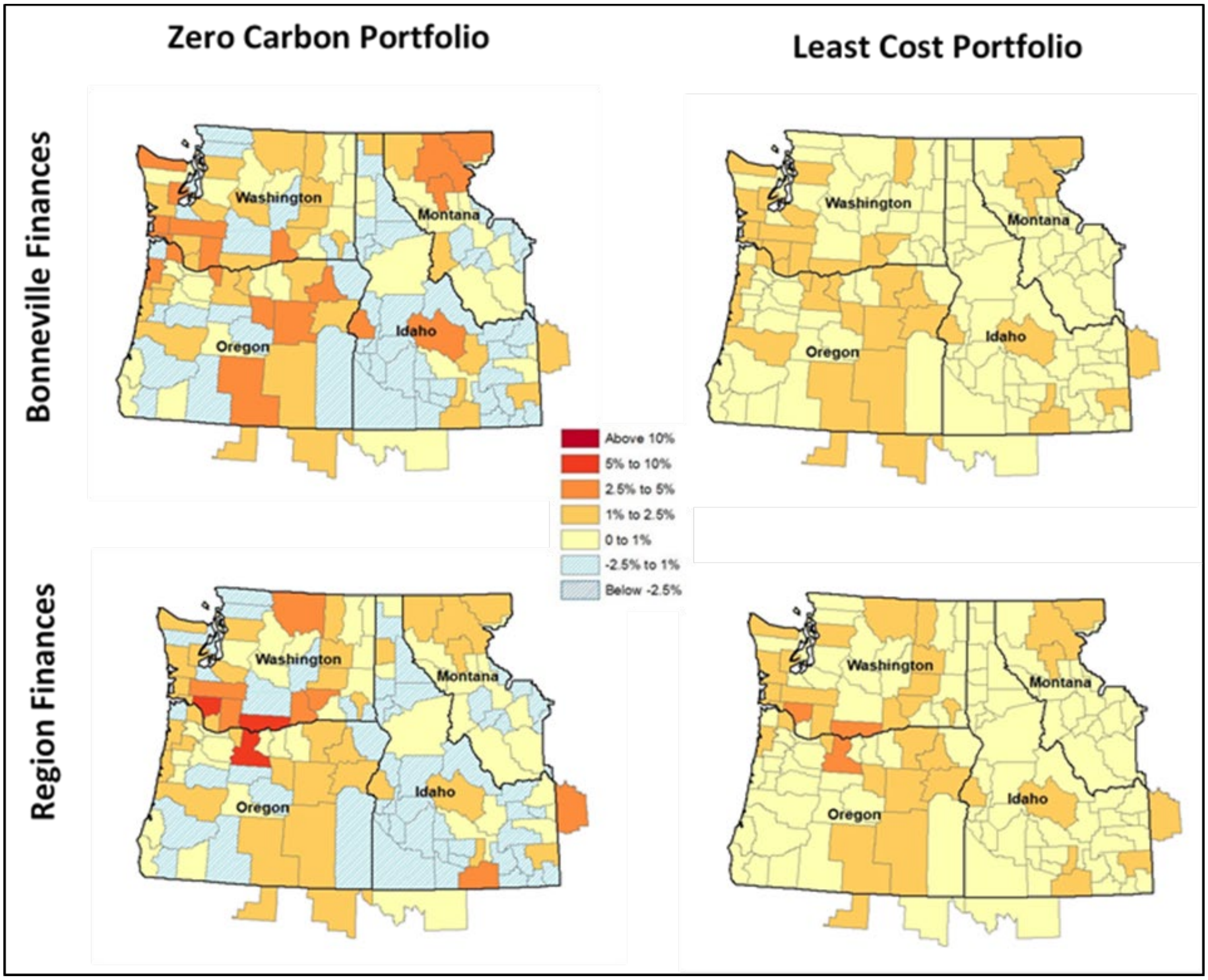


**Figure 3-180. Residential Electricity Rate Pressure Effects of Multiple Objective 1 by Portfolio**

**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% |

**Table 3-140. Percentage of Residential End Users Who Experience Changes in Electricity 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% |

Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

The EIA estimates short- and long-term electricity elasticities for one, two, and three years out from price changes, as well as the long term at year 25. Appendix H presents these elasticity estimates (EIA 2015). Given the small upward rate pressure under MO1, the effect on residential demand would be less than 1 percent under MO1 in many counties. Some counties that experience slight downward rate pressure (benefits) and could increase consumption of electricity. Counties with the highest upward rate pressure could adjust consumption and save up to $7.7 per year.

This analysis considers how the region wide changes in household spending on electricity would affect demand for other goods and services across the region. That is, increased spending on electricity may reduce spending on other items, affecting regional economic productivity. This analysis applies IMPLAN to model the increased spending on electricity as a reduction in household income (direct effect) and quantifies the multiplier effects on interrelated economic sectors (indirect and induced effects). This analysis finds that the potential increased cost of household electricity could result in the loss of between $37 million and $43 million in regional output (sales) and between 240 and 270 jobs (Table 3-141). The majority of regional economic effects would occur Washington and Oregon.

**Table 3-141. Regional Economic Effects from Changes in Household Spending on Electricity 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 |

Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy.

**Commercial and Industrial Effects**

Commercial and industrial rates under MO1 would also experience upward rate pressure compared to the No Action Alternative. Counties with the largest percentage of businesses in the region (King, Pierce, Snohomish and Multnomah Counties) would experience upward rate pressure under MO1 ranging from 0.3 to 2.6 percent relative to the No Action Alternative depending on the portfolio. Some counties would experience downward rate pressure; however, these are predominantly counties that do not have a large number of commercial end users. Table 3-142 presents the fraction of commercial and industrial end users that would experience upward rate pressure potentially leading to increases in expenditures on electricity above certain thresholds under MO1 compared to the No Action Alternative.

Relative to the No Action Alternative, expenditures on electricity would increase for both commercial and industrial end users. The average increases for commercial end users would range from $3.3 per month up to $3.8 per month depending on the replacement resource portfolio and financing portfolio. Over time, these increases would widen with continued rate pressure and the uncertainty of retail rate growths. Industrial end users would spend, on average, $40 to $47 more per month under MO1 relative to No Action. Many of the increases in the industrial rate would occur in counties without large numbers of industrial businesses (e.g., less than 0.2 percent of all regional industrial customers).

**Table 3-142. Percentage of Commercial and Industrial End Users Who Experience Changes in 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% |

Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

Under MO1, the total upward rate pressure across commercial businesses in the Pacific Northwest would be between $11 million and $13 million per year. This analysis uses the IMPLAN model to quantify the multiplier effects of the change in commercial sector productivity (Table 3-143). The multiplier effects reflect how the increased costs of doing business may affect demand for inputs to production across commercial businesses. This analysis finds that the increased cost of electricity to regional commercial businesses would result in the loss of between $18 million and $21 million in regional output (sales) and between 120 to 140 jobs depending on the replacement scenario. The majority of regional economic effects would occur Washington and Oregon.

**Table 3-143. Regional Economic Effects from Changes in Commercial Business Spending on 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 |

Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy

Under MO1, the total increase in spending on electricity across industrial businesses in the Pacific Northwest would be between $40 million and $46 million per year. Similar to the commercial spending analysis, the IMPLAN model is used to quantify the multiplier effects of the change in industrial sector productivity (Table 3-144). This analysis finds that the increased cost pressure to regional industrial businesses would result in the loss of between $65 million to $76 million in regional output (sales) and between 420 to 490 jobs. Again, the majority of regional economic effects would occur Washington and Oregon.

**Table 3-144. Regional Economic Effects from Changes in Industrial Business Spending on 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 |

Note: 1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy

The effects on commercial and industrial businesses described above is predicated on the region acquiring replacement resources for the reduction in hydropower generation. If the replacement resources are not developed, there would be an increased risk to power system reliability. Power shortages might occur in about 1 in 9 years. These power shortages (blackouts) would have adverse effects on the region as a whole, including commercial and industrial end users.

**Other Social Effects**

Under MO1, expenditures on residential electricity would remain within historical bounds and are unlikely to create negative health and safety concerns related to energy insecurity. This is because rates would remain relatively low, especially relative to income growth and slow load growth (American Council for an Energy-Efficient Economy 2017; EIA 2018a). Under MO1, no power system reliability effects would occur if replacement resources return LOLP to the No Action level so the potential for additional safety concerns related to power outages is unlikely to differ relative to the No Action Alternative. However, if the region (Bonneville or other regional entities) does not acquire additional resources, there would be an increased risk of power shortages and blackouts, which could lead to additional safety concerns. The risk of having a year with significant power shortages would nearly double. Because it can take many years to plan, site, permit, and construct new resources, the region might face this increased reliability risk after hydropower generation is reduced in MO1 until the new resources are available.

**SUMMARY OF EFFECTS**

Hydropower generation from the CRS projects would decrease by 130 aMW (roughly the amount of power consumed by 100,000 Northwest homes, or a city about the same size as Everett, Washington in a year) relative to the No Action Alternative on average under historical water conditions. The FCRPS would lose 290 aMW of firm power available for long-term, firm power sales to preference customers under critical water conditions. MO1 increases the LOLP to 11 percent due to the loss of hydropower, primarily in August, and would require replacement resources to return the region to the No Action Alternative LOLP of 6.6 percent. To replace the lost hydropower for power system reliability, the replacement resources not only need to replace the average energy but also replace some of the peaking ability of the hydropower system. Therefore, the amount of replacement resources (e.g., 560 MW gas) exceed the amount of average power lost (-130 aMW). These replacement resources would increase the wholesale transmission rate pressure and wholesale power costs for regional ratepayers under MO1.

The reduction in hydropower generation across the Pacific Northwest (a reduction of 170 aMW including Federal and non-Federal projects) results in an average annual economic cost of $25 million when valued at the market price of the foregone power generation. However, the estimated increase in the marginal cost of producing power to meet demand based on additional average annual fixed and variable costs is $64 million to $170 million. If these social welfare effects persist over a 50-year timeframe, the present value cost is up to $4.6 billion. These values are estimates of the net economic effects from a national societal perspective.

Regional utilities that purchase most or all of their power from Bonneville would experience larger upward rate pressure under MO1 than IOUs or other public utilities that do not purchase

Bonneville power directly. For most consumers, however, retail rates would experience slight upward rate pressure and consumers may pay more per year for electricity. Overall, MO1 would result in few entities (0 percent of households and 0 to 0.5 percent of businesses, depending on the portfolio) experiencing upward rate pressure of greater than 5 percent compared to No Action. But for those entities experiencing upward rate pressure greater than 5 percent, the effect would be moderate to major (Table 3-145). If the region did not acquire additional resources to replace the reduction in hydropower generation, then there would be an increase in the risk of power shortages (blackouts).

**Table 3-145. Summary of Effects under Multiple Objective 1 without Additional Coal Plant 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 $3.9 million |
| Average Bonneville wholesale power rate pressure (base analysis)<br>Potential Range of Bonneville wholesale power rate ($/MWh)<br>Potential range of Bonneville wholesale power rate pressure including rate sensitivities | $34.56 | +4.5% to +8.6%<br>$36.14/MWh to $37.53/MWh<br>5.6% to +14.4% |
| Annualized transmission rate pressure relative to NAA (%) | ——[/1] | +0.62% to +0.74% |
| Average annual social welfare effects ($): 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%<br>(-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%<br>(-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%<br>(-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 |

Note: The estimated LOLP effect, and resulting social welfare and rate effects, rely on the best available information regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis. Based on regional energy policy developments and expected coal-plant closures as of 2019, Section 3.7.3.1 discusses the sensitivity of the results of the analysis to these assumptions.

1/ The analysis of the No Action Alternative for these effect categories provides a baseline against which the MOs are compared. Thus, the No Action Alternative results presented in this table describe the baseline magnitude of power and transmission values (e.g., for LOLP and rates) and the MO1 results describe the change relative to No Action. A "——" indicates an effect category that is not relevant to the No Action Alternative because it only occurs as a result of implementing the MOs (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ The production cost method for valuing social welfare effects of the MOs relies on information on the fixed and variable costs of replacement generation resources. These costs are not relevant to the No Action Alternative.

The increased cost of electricity could slightly increase the costs of living and doing business in the Pacific Northwest, resulting in adverse regional economic impacts of $140 million in lost output (sales) and 900 jobs.

#### *3.7.3.4 Multiple Objective Alternative 2*

This section evaluates effects under MO2. Hydropower generation would increase under MO2 and the additional generation would increase power and system reliability (i.e., reduce LOLP) relative to the No Action Alternative. The effects of increased hydropower generation would result in downward rate pressure on wholesale-electricity rates, market prices, and thus downward rate pressure on retail rates for end users under MO2 relative to the No Action Alternative.

**CHANGES IN POWER GENERATION**

Table 3-146 and Figure 3-181 present the generation for the No Action Alternative and MO2 and their differences by month. Overall, generation from the CRS projects would increase from 8,300 aMW under the No Action Alternative to 8,800 aMW under MO2 on average for all water conditions. This represents an increase of 450 aMW, or a 5 percent increase in annual generation. For the northwest U.S. system, including non-Federal projects, the increase is also 450 aMW since the gain in generation is primarily from changes in spill that only affect the CRS projects.

**Table 3-146. Monthly Electricity Generation at Columbia River System Projects under Multiple 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%** |

Notes: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding. HYDSIM modeling inadvertently omitted the impact of the *Winter System FRM Space* in December of some years, which would move some generation (0 to 450 MW depending on the year) from January into December. This operation would not change the conclusions of the analysis.

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

Source: HYDSIM modeling results

Generation would increase during most months of the year for an average water year. Two measures have the largest impact on generation in MO2 as measured in HYDSIM. The *Slightly Deeper Drafts for Hydropower* measure increased winter storage draft volumes and generation. *Spill to* near 110*% TDG* reduced volumes and duration of spill for fish passage.

Under MO2, the critical water year generation of the CRS projects would increase by 6 percent (+380 aMW) compared to the No Action Alternative and the available firm power for long-term contracts would increase by 370 aMW. This increase would be largest in August when generation would increase by 20 percent due to ending summer spill. The ability of CRS projects to meet peak and heavy load periods would increase by 5 percent for both periods compared to the No Action Alternative.

Other non-Federal regional hydropower projects (such as the Mid-Columbia hydro projects whose operations are hydrologically coordinated with CRS projects) would experience similar winter trends in hydropower generation to the CRS projects, but would not be impacted from changing spill at the CRS projects. The regional hydropower system (including these non-CRS projects) under MO2 would generate 14,000 aMW in an average water year. This represents a 3 percent increase in power generation relative to the No Action Alternative. The CRS projects account for 445 aMW of the 453 aMW increase under MO2. Based on a qualitative assessment of the alternative, MO2 would increase the flexibility of operating the CRS projects, which would increase the ability to integrate other renewable resources into the power grid.

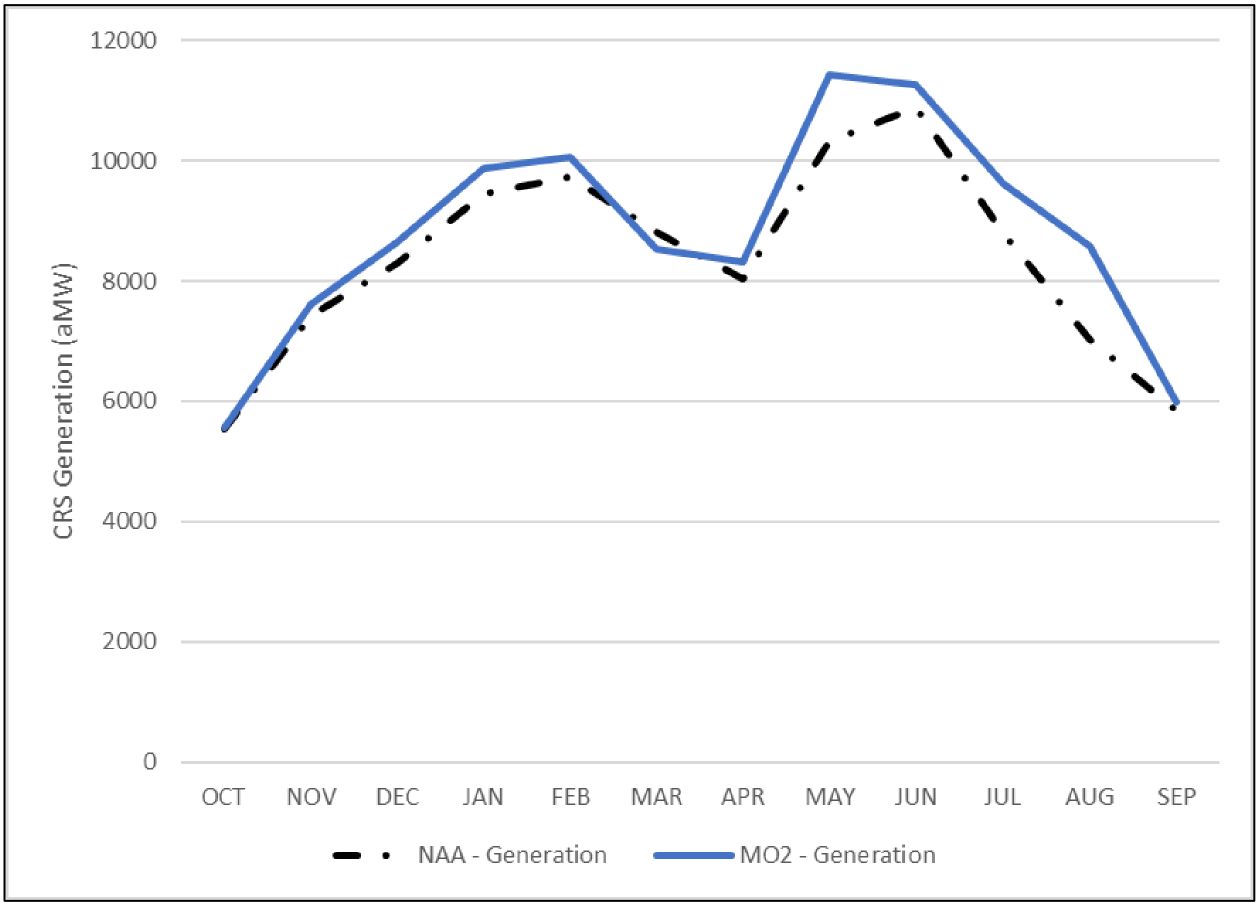


**Figure 3-181. Monthly Hydropower Generation at the CRS Projects, No Action Alternative and Multiple Objective 2, in aMW**

**EFFECTS ON POWER SYSTEM RELIABILITY**

The increases in power generation under MO2 would improve power system reliability and push out the timing of when regional resource builds would be required. The LOLP measured under MO2 would be 5 percent. This is below the LOLP of the No Action Alternative by 1.6 percentage points and would meet the NW Council target for power system reliability.

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 over the study period. In the scenarios with limited or no coal generation in the region, the LOLP under MO2 would decrease by 11 percentage points from an LOLP of 27 percent in the No Action Alternative to 16 percent in MO2 (limited coal), and 14 percentage points in MO2 from 63 percent to 49 percent (no coal), respectively. The difference between MO2 and the No Action Alternative is larger in the two scenarios with the additional coal plant closures than in the base analysis, due to the loss of baseload resources. In other words, factoring in the additional coal plant closures makes

MO2 even more beneficial for regional power reliability compared to the No Action Alternative than was identified in the base analysis.

**POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

MO2 would not require replacement resources to maintain the same level of power system reliability as the No Action Alternative. MO2 has a lower LOLP than the No Action Alternative. An alternate way to assess the benefit of this additional reliability in MO2 is to identify what resources MO2 avoids building for the No Action Alternative because of the improved reliability. In the base case without additional coal plant retirements, the avoided build of new resources (i.e., the benefit of MO2 reducing LOLP) under MO2 relative to the No Action Alternative would be 440 MW of natural gas for the least-cost resource portfolio or 660 MW of wind generation in Montana, 250 MW of solar generation, and 600 MW of demand response for the zero-carbon resource portfolio. The difference in LOLP for MO2 and the No Action Alternative is influenced by the effects in winter, when solar power generates less, and wind power located in Montana was the least-cost of the zero-carbon options relative to reducing the LOLP. Because available transmission capacity from Montana appears to be about 660 MW, the portfolio considered here likewise reflects that limitation.

As discussed in Section 3.7.3.2 and shown in Table 3-147, in future scenarios with limited or no coal generation no incremental zero-carbon resources would be needed to restore regional LOLP to the No Action Alternative level. That is, if MO2 were in effect, and either the limited coal capacity or the no coal capacity scenario occurred, the region would not need to acquire any more resources for MO2 than it would have otherwise acquired under the No Action Alternative.

**Table 3-147. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 2 Relative to the No Action Alternative**

| | Base Case Coal Capacity Assumption in EIS (4,246 MW) | | | More Limited Coal Capacity (1,741 MW) | | | No Coal Capacity (0 MW) | | |
|---|---|---|---|---|---|---|---|---|---|
| Alternative | 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 |

Notes: The replacement resources for No Action include demand-response, wind, and solar.

### BONNEVILLE FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION PLAN COSTS

Funding decisions for the Bonneville Fish and Wildlife Program are not being made as a part of the CRSO EIS process. However, Bonneville Fish and Wildlife Program costs are included in the EIS to inform a transparent cost analysis for each MO, as discussed in Section 3.19. Future budget adjustments would be made in consultation with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements. In the case of MO2, Bonneville included a range of potential Fish and Wildlife Program costs to acknowledge the possibility that MO2 could have additional impacts to fish and wildlife and that this could, in turn, increase the need for some offsite mitigation funded through the Bonneville Fish and Wildlife Program. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its Fish and Wildlife program and also acknowledges the uncertainty around both the magnitude of biological impacts and the potential impacts on funding, including the timing of funding decisions.

The base case analysis in the summary rate table includes an estimate of $316 million in annual costs (2019 dollars) for the Bonneville Fish and Wildlife Program and LSRCP together, which is consistent with the No Action Alternative. Potential increases to the Bonneville Fish and Wildlife Program, which are estimated to range up to $53 million, are analyzed as part of the Rate Sensitivity analysis. Future budget adjustments would be made in consultation with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements.

### EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE

#### Bonneville Interconnections

As the LOLP under MO2 would be lower than the No Action Alternative, no replacement resources would be needed, and no new interconnections or reinforcements would be required.

#### Bonneville Transmission System Reliability and Operations

Under MO2, Bonneville would continue to meet its transmission system reliability requirements. While average hydropower generation would increase under MO2, the peak output of the CRS projects would not increase. Since the transmission system already integrates the existing peak resource generation levels, the expected hydropower generation from MO2 should not result in additional transmission system reliability issues. As a result, no additional reinforcements have been identified beyond those that are a part of Bonneville's regular system assessments.

**Regional Transmission System Congestion Effects**

Under MO2, due to changes in hydropower and other amounts of generation, congested hours under low runoff conditions would decrease slightly from the No Action Alternative, and congested hours under median and high runoff conditions would increase slightly.

Under any runoff condition, small (less than 50 hours) changes in the number of congestion hours relative to the No Action Alternative would occur on the north-to-south paths.

In both median and high runoff conditions when more hydropower generation is occuring, most west-to-east paths would experience a higher number of congested hours, the largest being the Hemingway to Summer Lake transmission paths. See Appendix H for more detailed congestion graphs.

Overall, changes in the patterns of CRS generation under MO2 would have a relatively small or minor impact on congestion for most Pacific Northwest transmission paths and a minor to moderate increase in congestion hours for some west-to-east paths during median and high runoff conditions.

**ELECTRICITY RATE PRESSURE**

**Bonneville Wholesale Power Rates**

Under MO2, the average wholesale power rate for preference customers would experience downward rate pressure relative to the No Action Alternative. Should the downward rate pressure lead to rate decreases, the expected average wholesale power rate would be $34.28 per MWh, which represents a decrease (benefit) of $0.28 per MWh or an 0.8 percent decrease relative to the No Action Alternative in the base case without accounting for additional coal plant retirements.

The costs of structural measures at various CRS projects under MO2 would largely offset the downward rate pressure otherwise associated with the increased hydropower generation. In total, annualized structural measure costs were $57 million per year (2019 dollars). Specifically, adding a powerhouse surface passage route at McNary Dam with a feature for collection of juvenile fish for transport accounts for nearly $50 million in additional annual costs.[69] Without including those costs, the wholesale power rate under MO2 experiences downward rate pressure closer to $1.3 per MWh, or 4 percent, relative to the No Action Alternative. Although MO2 also calls for installation of powerhouse surface passage structures at the Ice Harbor and John Day projects, the structures for those projects cost considerably less because they do not include fish collection facilities. If MO2 is chosen as the preferred alternative, the results of this analysis suggest that it would be much more cost effective to continue the use of fish screens 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.

Summary results for Bonneville's wholesale power rate pressure analysis are presented in the first section of Table 3-148. As discussed in Section 3.7.3.1, the second section of Table 3-148 provides the cost pressure (or savings) to the region of MO2 in light of potential carbon compliance and accelerated coal retirements.

**Table 3-148. Average Bonneville Wholesale Power Rate ($/MWh) Under Multiple Objective 2, for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures 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 | |

Notes: Line 11 refers to the option of not designing powerhouse surface passage structure at McNary with an expensive feature for fish collection a more cost-effective option is available.

Line 14 represents the approximate range in fixed costs for replacement resources for the more limited coal scenario and the no coal scenario. Additional changes in value, denoted by line 15, would occur from changes in market prices, changes in technology, and many other factors. Because the retirement of coal plants in the region will change the utility landscape far from the current condition, there is not enough information available to extrapolate from today's information. Base rate includes Colville Settlement Payment, which decreases by 2 percent from the No Action Alternative.

***Base Case Analysis***

Base rate results show downward rate pressure of 0.8 percent relative to the No Action Alternative. In this alternative, no replacement resources were needed to return the region to the No Action Alternative level of LOLP. Therefore, only incremental cost pressures and load effects were analyzed. Expected cost increases of $16 million per year (2019 dollars) put upward pressure on power rates relative to the No Action Alternative, while the increase in preference loads contributes to 1.6 percent downward rate pressure. Rate pressures are driven by higher capital costs associated with the structural measures, offset by increased generation and sales.

***Rate Sensitivity Analysis***

Rate sensitivities are presented in Table 3-148, lines 5 through 11 to provide quantitative estimates relative to the additional sensitivity analyses described in Section 3.7.3.1. The cost analysis showed that Bonneville's fish and wildlife expenses could be as much as $53 million per year higher in MO2 than in the No Action Alternative, owing to higher generation and lower spill and the need for increased mitigation efforts. Because no replacement resource was selected in the LOLP, no sensitivities to resource are analyzed. OMP costs associated with oversupply events could be $3 to $4 million per year higher compared to the NAA.

***Other Regional Cost Pressure***

Cost pressures to regional utilities, which do not necessarily impact Bonneville's power rates, but could in the future, are presented in lines 13 and 14. Effects associated with regional carbon compliance laws are unknown, pending current legislation in Oregon and Washington as discussed in Section 3.7.3.1. If binding estimates effective in the future are enforced to the resource portfolio in MO2, regional utilities could face cost savings relative to the No Action Alternative of $37 to 194 million per year.

As described in Sections 3.8.3.1, Availability of Coal Resources subsection, and 3.8.3.2, Effects on Power System Reliability subsection, regional utilities would need to add 8,800 MW of additional zero-carbon resources in the limited coal capacity scenario and 28,000 MW of additional zero-carbon resources in the no coal scenario to maintain regional LOLP at No Action Alternative levels (6.6 percent). Lines 14 and 15 estimate the incremental zero-carbon resources costs needed by the region to maintain the No Action Alternative LOLP of at least 6.6 percent under MO2 in light of a limited or no coal assumption. An "incremental zero-carbon resource cost" occurs if the combination of (1) the resources Bonneville or the region is expected to acquire under the MO, plus (2) 8,800 MW (under the limited coal scenario) or 28,000 MW (under the no coal scenario), is less than the total amount of zero-carbon resources needed to return the region to the No Action Alternative LOLP of 6.6 percent.

For the limited coal capacity scenario under MO2, a minimum of 5,900 MW of zero-carbon resources would need to be added by the region to maintain regional LOLP at the No Action Alternative level of 6.6 percent. For the no coal scenario under MO2, a minimum of 22,000 MW of zero-carbon resources would be needed to maintain regional LOLP to No Action Alternative levels. Since both of these starting values are below the No Action Alternative's 8,800 MW (for limited coal) and 28,000 MW (for no coal), no incremental zero-carbon resource costs would be incurred as a result of this MO under either a limited or no coal scenario.

**Market Prices**

Market prices would be expected to experience downward price pressure, potentially leading to decreases in price to $18.77 per MWh under MO2 due to the increase in hydropower generation and additional surplus power (2019 dollars). This effect would be a decrease of $0.65 per MWh or 3.3 percent relative to the No Action Alternative. Figure 3-182 presents the CRS projects' generation and the market prices under MO2 for the average of the 80 historical water years. Prices would peak in September when generation is low, while prices would be lowest in May and June when generation exceeds 11,000 aMW.

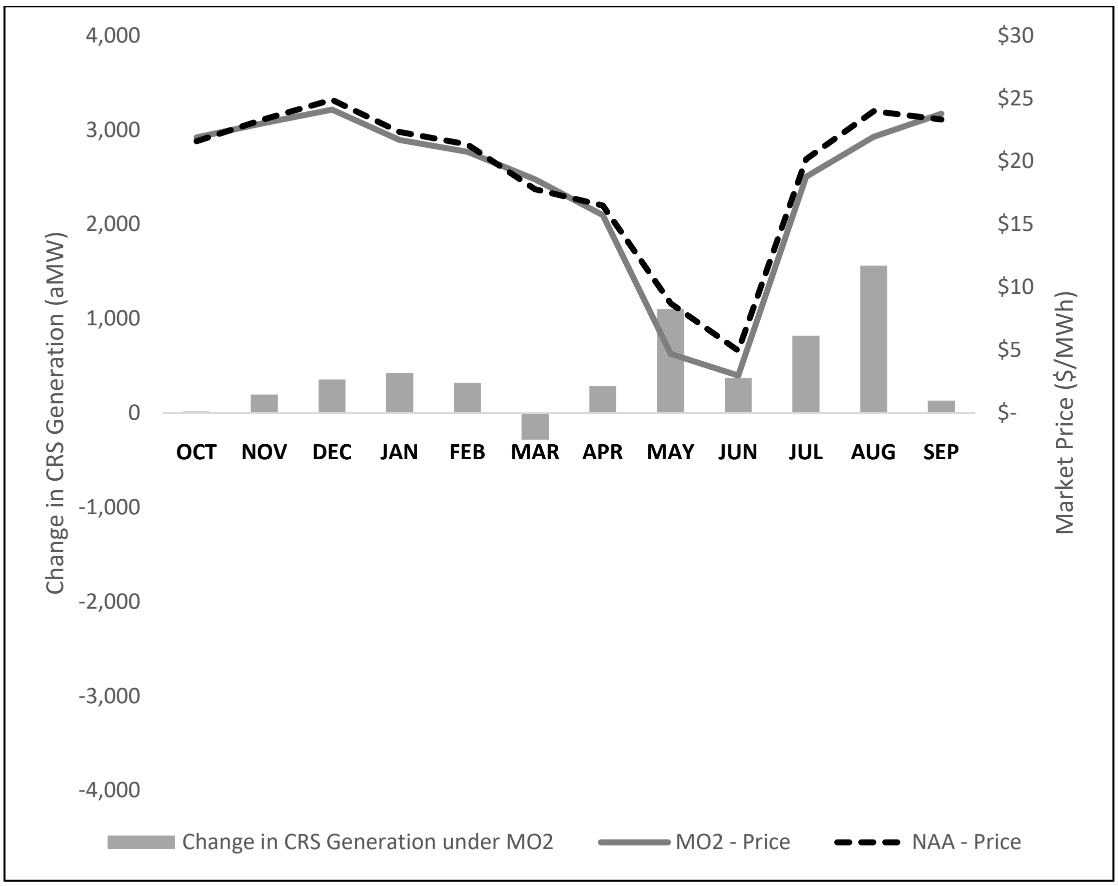


**Figure 3-182. Market Prices and Average CRS Hydropower Generation for the Base Case without Additional Coal Plant Retirements**

Note: The right axis is the market price ($/MWh). The left axis is generation from the CRS projects by month (aMW).

Source: Power Analysis

**Bonneville Wholesale Transmission Rate Pressure**

Under MO2, there would be no changes in capital investments or long-term transmission sales. The upward Bonneville transmission rate pressure would be about 0.11 percent annually (0.89 percent cumulatively over an 8-year period) relative to the No Action Alternative because transmission short-term sales would likely change as a result of the changes in hydropower generation and associated market pricing. For specific customers and product choices, the annualized upward rate pressure ranges from 0.05 to 0.23 percent.

**Retail Rate Effects**

Under MO2, retail electricity rates (paid to individual utilities) would remain similar to the No Action Alternative. Some counties would experience small increases while others would experience decreases in the electricity retail rate. Across the Pacific Northwest, changes to the retail rate would range from -0.092 cents to +0.042 cents per kWh for residential end users. For commercial end users, rate effects range from -0.092 cents to +0.038 cents per kWh, and for industrial customers, from -0.093 cents per kWh to +0.034 cents per kWh, relative to the No Action Alternative.

**BONNEVILLE FINANCIAL ANALYSIS**

As previously described, the Bonneville financial analysis considers the effects of the MOs on future cash flows over a 30-year financing period for potential replacement resources. For MO2, the NPV of the cash flow effects are described in Table 3-149. This NPV analysis is Bonneville specific and does not capture wider societal impacts. This NPV analysis uses a risk adjusted discount rate of 7.9 percent and a 30-year timeframe.

The sensitivities in this analysis are described in the Power Rates section, above.

**Table 3-149. Bonneville Financial Analysis Results (in Millions $2022)**

| Analysis Type | MO2 Zero-Carbon |
|---|---|
| Power | -$453 |
| Transmission | -$10 |
| **Total Base Impact – Bonneville** | **-$464** |

**SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

Except where noted, this section describes the base analysis for MO2 without considering the range of additional costs shown in Table 3-148 and without the retirement of additional coal-plants.

**Social Welfare Effects**

This social welfare analysis employs both the market price and production cost methods based on the base case for this analysis, assuming no additional coal plant retirements. Section 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*, describes the differences between these two methods. Table 3-150 presents the market value of the increase in Pacific Northwest hydropower generation under MO2 as compared with the No Action Alternative. Based on the market price method, the average annual economic effect of MO2 is a $75 million benefit. If these social welfare effects persist over a 50-year timeframe, the present value benefit would be $2.0 billion.

**Table 3-150. Average Annual Social Welfare Effect of Multiple Objective 2 Based on the 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** |

Table 3-151 evaluates the social welfare effects of MO2 in terms of the reduction in the costs of producing power due to the increased hydropower generation presented in Table 3-146. The social welfare effects are the reduction in the cost of fuel for fossil fuel-based generation due to the increased generation from hydropower under MO2 relative to No Action Alternative. The effects do not include the value of any improvement in the level of power system reliability associated with replacement resources under MO2, because MO2 does not require such resources. Based on this approach, the social welfare effect of MO2 is an average annual benefit of $55 million. If these social welfare effects persist over a 50-year timeframe, the present value benefit would be $2.2 billion. The resource portfolio equivalent to the improvement in power system reliability from the No Action Alternative to MO2 would have a value ranging up to $170 million. In the future scenarios of additional coal plant retirements, the value of MO2 increases.

**Table 3-151. Average Annual Social Welfare Effect of Multiple Objective 2 Based on the 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** |

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
1/ Positive values in the table represent a decrease (net benefit) in the cost of producing power.

### Regional Economic Effects

Under MO2, retail electricity rate effects would range from beneficial to adverse effects across the region. The average residential retail rate would experience downward rate pressure of a fraction of a cent per kWh, and average commercial and industrial rates would experience downward rate pressure of a fraction of a cent per kWh, such that the net effect would result in beneficial socioeconomic effects relative to the No Action Alternative.

**Residential Effects**

Residential retail rates would experience downward rate pressure across a large share of the counties in the Pacific Northwest under MO2. On average, residential rates would experience downward rate pressure, and the largest upward rate pressure would be 0.042 cents per kWh. Residential retail rate pressures under MO2 would range from a 1 to 0.46 percent increase to a 1.3 percent decrease. In addition, in the scenarios with limited or no coal in the region, there would be further downward rate pressure in MO2 than the No Action Alternative because the benefit to the power system of additional generation under MO2 would reduce the need to build new generating capacity.

Both urban areas and rural areas would potentially benefit from downward rate pressure under MO2 with the largest decrease occurring in urban counties with fewer than 20,000 residents and metro areas with fewer than 250,000 residents (residential rate decreases between -0.56 and -0.54 percent). CRSO Regions A, D and “other” would experience the largest average downward in residential rate pressure of 0.40 percent, 0.37 percent, and 0.40 percent (Table 3-152).

**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% |

Figure 3-183 presents the estimated change in retail rates on a geographic basis relative to the No Action Alternative. As illustrated in this figure, the residential retail rates experience downward rate pressure across much of the region with a few counties that experience upward effects.

To the extent that the downward rate pressure leads to changes in rates, end users would decrease spending on electricity (Table 3-153). As a percentage of income across the region, income for the average household under MO2 would also increase mildly relative to the No Action Alternative by less than 0.05 percent. Some households would experience benefits with reductions of up to 1.7 percent of their expenditures on electricity. Roughly three percent of all households in the region would experience increases between 0 and 1 percent in their average electricity expenditures while 97 percent would experience beneficial decreases in their average expenditures.

Given the relatively small changes in rates, the effects on the demand for electricity would also likely be small. Residential end users could adjust their consumption based on changes between -1.3 and 0.46 percent, varying by the county rate effect. These consumption decisions in MO2 would lead to a range of effects across counties with households either saving up to $4.5 per year or consuming more electricity and spending $9.5 more per year for the highest and lowest rate changes. On average, households would experience a less than 1 percent change with annual savings of less than $1. The total decrease in household spending on electricity across all Pacific Northwest households would be $24 million per year under Multiple Objective 2.

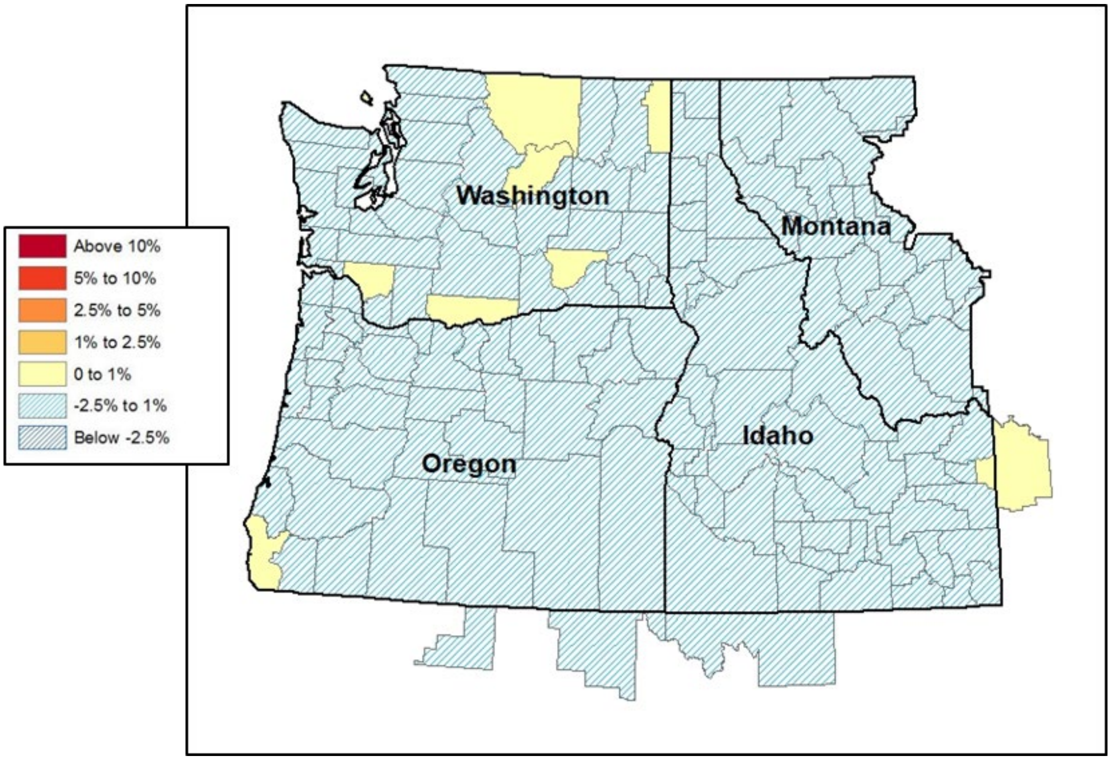


**Figure 3-183. Residential Rate Pressure Effects under MO2 Relative to the No Action Alternative**

**Table 3-153. Percentage of Residential End Users Who Experience Changes in Electricity 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% |

MO2 contained an expensive variation of a powerhouse surface passage structure at McNary dam that could also collect fish for transportation. If MO2 were implemented with fish collection at McNary, a significantly cheaper option would be likely be implemented. Not including the costly structure at McNary Dam would increase the power value MO2. Similarly, the scenarios with limited or no coal would each increase the power value of the MO2 relative to the No Action Alternative and would decrease the power rates and expenditures relative to the No Action Alternative.

This analysis considers how the region-wide changes in household spending on electricity would affect demand for other goods and services across the region. That is, under MO2 the decreased spending on electricity may increase spending on other items, affecting regional economic productivity. This analysis applies IMPLAN to model the decreased spending on electricity as an increase in household income (direct effect), and quantifies the multiplier effects on interrelated economic sectors (indirect and induced effects). This analysis finds that the potential decreased cost of household electricity would result in gains of $25 million in regional output (sales) and 170 jobs (Table 3-154). The majority of regional economic effects would occur Washington and Oregon.

**Table 3-154. Regional Economic Effects from Decreases in Household Spending on Electricity under Multiple Objective 2**

| Effect | MO2 |
|---|---|
| Output | +$25 million |
| Value Added | +$15 million |
| Labor Income | +$8.3 million |
| Employment | +170 jobs |

Note:1/ Positive values in the table represent an increase (net benefit) in the output and employment of the regional economy

**Commercial and Industrial Effects**

Under MO2, commercial and industrial rates would experience downward rate pressure for a majority of end users with small upward effect in some counties. Average commercial and industrial end users would experience a 0.48 percent decrease and 0.58 percent increase, respectively. The counties with the largest number of commercial entities would experience a -0.72 to -0.12 percent downward commercial rate pressure effect. For industrial end users, the average retail rate in these counties under MO2 would also experience a downward pressure effect, by -0.26 percent to -1.0 percent relative to the No Action Alternative.

For the average industrial end user, MO2 would result in expenditures not changing noticeably compared to the No Action Alternative. For the average end user, MO2 would result in slightly lower expenditures for industrial users, by 0.58 percent, and slightly lower expenditures for commercial users, by 0.48 percent, compared to the No Action Alternative. A majority (98 percent) of industrial customers would experience decreases in their expenditures and a majority (97 percent) of commercial end users would experience a downward rate pressure in their retail rates. The largest single-county reduction in industrial expenditures on electricity is $2,800, or 1.1 percent of No Action Alternative levels. Table 3-155 presents the fraction of commercial and industrial end users that would experience increases in expenditures above certain thresholds under MO2 compared to the No Action Alternative.

For MO2, no commercial or industrial end users would experience increases above 2.5 percent relative to the No Action Alternative. The majority of users would face a decrease. Without the costly fish-collection structure at and McNary Dam, rates would likely decrease in all categories.

Similarly, in the scenarios with limited or no coal, the rates would likely decrease relative to the No Action Alternative.

**Table 3-155. Percentage of Commercial and Industrial End Users Who Experience Changes in 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% |

Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

Under MO2, the total potential decrease in spending on electricity across commercial businesses in the Pacific Northwest would be $8.0 million per year. This analysis uses the IMPLAN model to quantify the multiplier effects of the change in commercial sector productivity (Table 3-156). The multiplier effects reflect how the decreased costs of doing business affect demand for inputs to production across commercial businesses. This analysis finds that the decreased cost of electricity to regional commercial businesses would result in potential gains of $14 million in regional output (sales) and 97 jobs. The majority of regional economic effects would occur Washington and Oregon.

**Table 3-156. Regional Economic Effects from Decreases in Commercial Business Spending on Electricity under Multiple Objective 2**

| Effect | MO2 |
|---|---|
| Output | +$14 million |
| Value Added | +$8.3 million |
| Labor Income | +$4.3 million |
| Employment | +97 jobs |

1/ Positive values in the table represent an increase (net benefit) in the output and employment of the regional economy

Under MO2, the total potential decrease in spending on electricity across industrial businesses in the Pacific Northwest would be $26 million. Similar to the commercial spending analysis, the IMPLAN model is used to quantify the multiplier effects of the change in industrial sector productivity (Table 3-157). This analysis finds that the decreased cost of electricity to regional industrial businesses could result in the gain of $44 million in regional output (sales) and 30 jobs. Again, the majority of regional economic effects would occur Washington and Oregon.

**Table 3-157. Regional Economic Effects from Decreases in Industrial Business Spending on Electricity under Multiple Objective 2**

| Effect | MO2 |
|---|---|
| Output | +$44 million |
| Value Added | +$27 million |
| Labor Income | +$14 million |
| Employment | +300 jobs |

Note:1/ Positive values in the table represent an increase (net benefit) in the output and employment of the regional economy

### Other Social Effects

Under MO2, expenditures on residential electricity would change very slightly and would be reduced for many households. Based on the expected rate decreases or small increases, MO2 would be unlikely to create an energy burden on household consumers and would not be expected to cause households to forego expenditures due to changes in electricity bills. Under MO2, no reliability effects would occur and LOLP would improve relative to the No Action level so that the reduced risk of safety concerns related to power outages would be a beneficial effect compared to the No Action Alternative.

### SUMMARY OF EFFECTS

Under MO2, hydropower generation would increase relative to the No Action Alternative, and the FCRPS would gain 370 aMW of firm power available for long-term firm power sales (roughly the amount of power consumed by about 300,000 Northwest homes in a year). The increase in hydropower generation would reduce LOLP, improve power system reliability, and lower electricity costs.

The increase in hydropower generation across the Pacific Northwest (an increase of 450 aMW including Federal and non-Federal projects) results in an average annual economic benefit of $75 million when valued at the market price of power generation. The estimated reduction in the marginal cost of producing power to meet demand is $82 million. If these social welfare effects persist over a 50-year timeframe, the present value benefit would be up to $2.2 billion. These values are estimates of the net economic benefits of MO2 from a national societal perspective.

Both residential and commercial end users would experience minor downward rate pressure effects up to a decrease of 2 percent to minor upward effects of below 1 percent in average rates. A minority of end users would experience upward rate pressure effects under MO2.

The decreased cost of electricity would decrease spending on electricity for households and businesses resulting in a gain of $82 million in output (sales) and 560 jobs in the region. Without the costly fish-collection structure at McNary Dam, rates would likely lower further in all categories. Similarly, in the scenarios with limited or no coal, the rates would likely decrease in all categories relative to the No Action Alternative (Table 3-158). Regional utilities that purchase most or all of their power from Bonneville could experience larger effects than IOUs or other public utilities that do not purchase Bonneville power directly.

**Table 3-158. Summary of Effects under Multiple Objective 2 without Additional Coal Plant 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 -$140 million[2/] |
| Transmission infrastructure to return LOLP and/or transmission system reliability to NAA level (annualized reinforcement and/or interconnection cost) | ——[1/] | ——[2/] |
| Average Bonneville wholesale power rate pressure (base analysis)<br>Potential Bonneville wholesale power rate ($/MWh)<br>Potential range of Bonneville wholesale power rate pressure including rate sensitivities | $34.56 | -0.8%[3/]<br>$34.28/MWh<br>-0.7% to +1.9% |
| Annualized transmission rate pressure relative to NAA (%) | ——[1/] | +0.11% |
| Average annual social welfare effects ($): 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%<br>(-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 %<br>(-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%<br>(-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 |

Note: The estimated LOLP effect, and resulting social welfare and rate effects, rely on the best available information regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis. Based on regional energy policy developments and expected coal-plant closures as of 2019, Section 3.7.3.1 discusses the sensitivity of the results of the analysis to these assumptions.

1/ The analysis of the No Action Alternative for these effect categories provides a baseline against which the MOs are compared. Thus, the No Action Alternative results presented in this table describe the baseline magnitude of power and transmission values (e.g., for LOLP and rates) and the MO2 results describe the change relative to No Action. A "——" indicates an effect category that is not relevant to the No Action Alternative because it only occurs as a result of implementing the MOs (e.g., the need for new generation and transmission infrastructure and associated costs).
2/ MO2 is assumed to result in avoidance of a need to build additional resources that would have been anticipated under the No Action Alternative. As such, replacement resource costs are negative, and social welfare effects are positive.
3/ This value would be -4 percent without the new McNary fish collection structure. That is, without the structure, wholesale rates under MO2 would be 4 percent lower than under the No Action Alternative.
4/ The production cost method for valuing social welfare effects of the MOs relies on information on the fixed and variable costs of replacement generation resources. These costs are not relevant to the No Action Alternative.

### *3.7.3.5 Multiple Objective Alternative 3*

This section evaluates effects under MO3. Losing generation due to breaching the lower Snake River projects and the increase in spring spill for juvenile fish passage under this alternative would reduce overall power generation and power system reliability. The loss of generation would also change flows on the transmission system. Replacement resources to bring LOLP to No Action Alternative levels would result in upward rate pressure under MO3 relative to the No Action Alternative.

In MO1, MO2, and MO4, operational changes impact the amount of power produced, but do not make major changes to the generating resources. MO3 removes generating resources from the system. As such, a number of metrics are relevant for MO3 that are not included in the effects analysis for the other MOs. These include an assessment of the debt still outstanding associated with the lower Snake River projects, the reduced capital, and large changes to operations and maintenance at the projects. Another contrast between MO3 and the other MOs pertains to the loss of the ability to generate from these projects in unforeseen and emergency conditions.

**CHANGES IN POWER GENERATION**

Table 3-159 and Figure 3-184 present the generation for the No Action Alternative and MO3 and their differences by month. Overall, generation from the CRS projects would decrease by 1,100 aMW from 8,300 aMW under the No Action Alternative to 7,200 aMW under MO3, on average, over all historical water conditions. This represents a greater than 13 percent decrease in generation. For the regional hydropower system, including the non-Federal projects, the decrease in generation would be 1,140 aMW. This represents a greater than 9 percent decrease in the U.S. regional generation. Generation would decrease throughout most of the year with the largest decreases in the winter, spring, and early summer months. Because generation from the lower Snake River projects would be eliminated under MO3, when compared to the No Action Alternative, this lack of generation generally accounts for these decreases. This is particularly true in the winter, spring, and early summer months when the lower Snake River projects typically generate the most power. Generation would also be diminished by increased fish passage spill at the lower Columbia River projects in the spring. Generation would increase in August as a result of ending fish passage spill at the lower Columbia River projects earlier than under the No Action Alternative.

**Table 3-159. Monthly Hydropower Generation at the Columbia River System Projects, 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%** |

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.
Source: HYDSIM modeling results

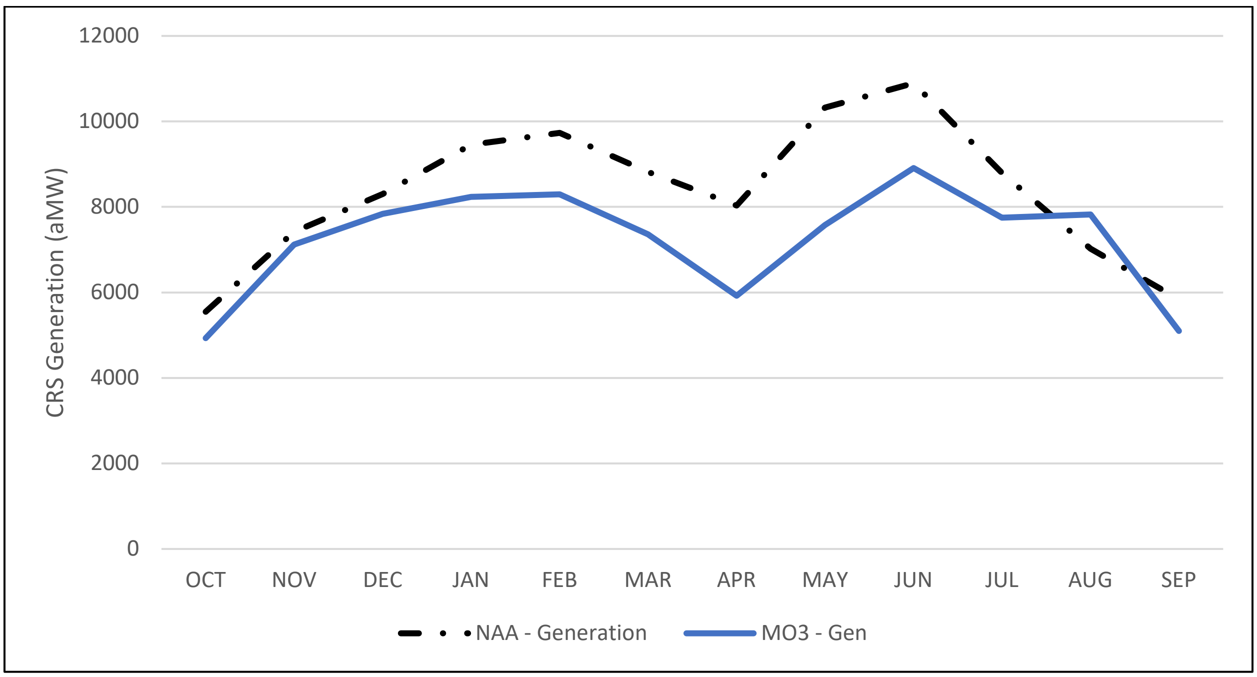


**Figure 3-184. Monthly Hydropower Generation at the Columbia River System Projects, No Action Alternative and Multiple Objective 3, in aMW**

Under MO3, the critical water year generation of the CRS projects would decrease by 12 percent (-750 aMW, from 6,200 aMW to 5,500 aMW) and the available firm power for long-term contracts would decrease by 730 aMW. This decrease would be largest in May when generation would decrease by 38 percent. The ability of CRS projects to meet peak load and heavy load periods would decrease by 11 percent and 9 percent, respectively.

Non-Federal hydropower projects that are located downstream of CRS projects (such as the mid-Columbia hydro projects) would not experience the effects in hydropower generation from dam breaching and spill changes. They would, however, experience effects from measures that alter flows in the upper- and mid-Columbia River such as changes in water management at Libby and additional irrigation withdrawals. The regional hydropower system (including certain non-CRS projects) under MO3 would generate 12,000 aMW, on average, over all modeled water years. This represents a 9 percent decrease in power generation relative to the No Action Alternative. The CRS projects account for 97 percent of the decrease under MO3.

Based on a qualitative assessment of the alternative, MO3 includes measures that increase and measures that decrease the flexibility of the hydro-system. This flexibility is useful to integrate the variability of other renewable resources. The loss of generation at the lower Snake River projects and the increase in spill at the lower Columbia River projects reduces flexibility considerably. Conversely, allowing John Day to use a wider forebay operating range during the fish passage season, allowing the turbines to operate over a wider range and carrying contingency reserves within fish spill help to partially offset the reduction in flexibility.

**EFFECTS ON POWER SYSTEM RELIABILITY**

Due to the reduction in total hydropower generation under MO3, the LOLP under MO3 would be 14 percent, which is 7.3 percentage points higher LOLP than under the No Action Alternative, more than doubling the chances of a power shortage in the region. The change in LOLP results from changes in generation throughout most of the year from the loss of generation from the lower Snake River projects and increased spring spill at the lower Columbia River projects and increased irrigation withdrawals. There is an increase in generation in August due to the earlier end of summer spill at the lower Columbia River projects. A 14 percent LOLP is roughly equivalent to a one-in-seven likelihood of one or more loss of load events (such as a power outage) in 2022, more than double the LOLP under the No Action Alternative.

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 over the study period. In future scenarios with limited to no coal capacity, the LOLP under MO3 would increase by 16 percentage points relative to the No Action Alternative, depending on how much coal-fired generation remains in the region (from 27 percent to 43 percent in the limited coal scenario and from 63 percent to 79 percent with no coal). In the scenario with additional coal closures, the LOLP for the No Action Alternative is well above the NW Council target of 5 percent. Further, the difference between MO3 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. In other words, factoring in the additional coal plant closures causes MO3 to have a substantially more negative impact for regional power system reliability than was identified in the base analysis.

### POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS

To maintain power system reliability in the Northwest, additional generation resources would be needed. As with other MOs, two replacement resource portfolios were considered in the base case analysis to return regional LOLP to the No Action Alternative of 6.6 percent: (1) conventional least-cost; and (2) zero-carbon. Each is described in more detail below.

#### Conventional Least-Cost Replacement (Base Case Analysis)

Under the least-cost replacement generation portfolio, returning LOLP to the No Action Alternative level could be accomplished with approximately 1,120 MW of combined cycle natural gas turbines located in northeastern Oregon in a base case without additional coal closures. This portfolio would cost approximately $137 million annually including annualized capital costs, fixed operations and maintenance, fixed fuel transmission and insurance (2019 dollars). The annual cost of fuel to generate power would vary depending on annual power production. During critical water conditions, the fuel plus variable operations and maintenance costs would be roughly $112 million annually (2019 dollars).[70] If the lost generation is replaced by natural-gas fired power plants, then the replacement resources would not only return the LOLP to the same level as the No Action Alternative, but would also replace flexibility and base-load value of the generation lost due to dam breach in MO3.

#### Zero-Carbon Replacement (Base Case Analysis)

Under the zero-carbon replacement portfolio, approximately 2,550 MW of solar power resources and 600 MW of demand response would be needed to reduce regional LOLP to the No Action Alternative level. Operating with this replacement portfolio would also require increased generation from the existing gas and coal-fired plants in the region. The transmission analysis assumed solar resources would be located in central Oregon based on proposed projects in the generation interconnection queue as well as that being a location with high solar output. To provide a sense of scale, the region currently has about 1,000 MW of solar. These new solar-power resources would require roughly 14,000 acres (about 22 square miles) of land. Such a large build out of solar capacity would likely result in additional but currently unknown impacts to natural and cultural resources, which may include vegetation, wildlife habitat, archeological resources, and traditional cultural properties.

In addition to 2,550 MW of solar, analysis was conducted to determine whether other resources would be needed to replace the lost flexibility and generating capability of the lower Snake River projects. This additional step was developed in the latter stages of the base case analysis for MO3 to reflect that the lower Snake River projects would no longer be available to support regional power needs, including peaking capability, reserves, voltage support, inertia, 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.

hydropower generation, more than 2,000 MW of sustained peaking capabilities during the winter, and a quarter of Bonneville's current reserves holding capability. Adding 2,550 MW of solar, though sufficient to return regional LOLP to the No Action Alternative levels, would not replace the lost capacity and flexibility benefits provided by the lower Snake River projects to regional reliability and stability. The infusion of new intermittent renewable resources to replace lost generation from the lower Snake River projects would further stress the limited ramping capabilities and generation balancing reserves of the remaining CRS and other power plants in the region. Regional demand for ramping and generation services would, then, likely cause development of additional flexibility resources to replace the lost lower Snake River projects' capability. That demand would grow as the retirement of regional coal resources accelerates and state policies make replacing coal with natural gas less acceptable.

Developing a zero-carbon portfolio that would replace all attributes of the lower Snake River projects for the base case analysis was not possible given the time constraints with this analysis. Nonetheless, to reflect a portion of the costs of replacing the lost capability and flexibility of the lower Snake River projects under MO3, the base case analysis assumes that half of the 2,550 MW in installed solar capacity (1,275 MW) would be supported by battery or solar storage. Estimates for the costs of solar storage installation came from recent cost estimates from the NW Council.[71] The analysis returns a part of the lost flexibility in the base case analysis as a first step to developing a zero-carbon portfolio to replace the full capability of the lower Snake River projects. As discussed below, a more in-depth review of a zero-carbon replacement portfolio is developed in the lower Snake River replacement analysis.

Under the base case analysis, the zero-carbon portfolio of 2,550 MW of solar plus 1,275 MW of storage would cost $389 million per year. Demand response for 600 MW would add an additional $20 million[72] per year (2019 dollars).[73]

**Lower Snake River Full Replacement (Used in Rate Sensitivity Analysis)**

As discussed above, analytical and timing constraints prevented the base case analysis from incorporating a comprehensive zero-carbon replacement portfolio for the attributes of the lower Snake River projects under MO3. The need for that portfolio will likely increase as existing coal resources retire, and state policies prevent or deter the construction of additional dispatchable thermal resources (such as natural gas). This section explores the attributes, size, and costs of an expanded zero-carbon portfolio designed to replace the flexibility and capability of the lower Snake River projects. This analysis is not exhaustive and does not detail all costs estimates of replacing the lower Snake River projects. Instead, it outlines potential resource 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.

this section produces a range of costs that is used in the power rates analysis as a "rate sensitivity."

The lower Snake River projects have operational attributes that make them uniquely positioned to maintaining the electrical reliability and stability of the regional transmission system. Replacing the lower Snake River projects with resources of equivalent abilities requires an understanding of the various attributes, services, and benefits that the lower Snake River projects provide today. A brief description of some of these attributes is provided below.

- **Carbon Free:** The lower Snake River projects produce electric generation from water and are carbon free. A carbon free portfolio would include wind and solar resources, geothermal, nuclear small modular reactors (SMR), and storage technologies, such as pump storage and batteries (assuming they are charged with a carbon free generation source).
- **Low Cost:** The lower Snake River projects are some of the lowest cost dams of the FCRPS. Table 3-112 summarizes the average cost of generation at the projects.
- **Energy**: The lower Snake River projects produce on average around 1,000 megawatts of energy, which is roughly the amount of power it takes to power Seattle City Light's load. While there is variability in streamflow over a typical year, there is also a certain amount of energy that has a high probability of occurring and can be counted on from year to year. To provide replacement energy, the following are resource options: combined-cycle natural gas plants, wind, solar, nuclear SMRs, and geothermal.
- **Operating Reserves**: Bonneville uses the lower Snake River projects to provide balancing and contingency reserves. The lower Snake River projects are a part of the so-called 'big ten projects' within the FCRPS and are connected to automatic generation control allowing the lower Snake River projects to respond quickly to requested changes. The amount of actual reserves that Bonneville holds at the lower Snake River projects can change by project and by season due to such things as outages and water conditions. For planning purposes, 250 MW of operating reserves are assigned to the lower Snake River projects. To replace these characteristics, the following types of resources and technologies are possibilities: simple-cycle natural gas plants such as an LMS100 or frame, reciprocating engine, pumped storage, batteries, and geothermal.
- **Ramping Capability**: The lower Snake River projects have the unique ability during certain times of the year to back down their generation to very low levels at night and then increase (ramp) the generation during the day to meet daytime peaks. This ability may be less obvious when looking at only heavy load and light load hour generation. To assess the ability of the lower Snake River projects to ramp, Bonneville looked at actual generation to derive a sustained peak value (6 peak hours per weekday for a month). This value is representative of the average of the super-peak hours when the highest generation is needed. This super-peak value is used to represent what can be sustained over a period of time as opposed to a single hour of generation. Once the super-peak value was derived from historic generation, it was then compared to the minimum generation required of those projects, to derive how much the dams can ramp from minimum generation to a

sustained peak. Depending on the time of the year, this can be over 2,000 MW. Also of significant importance is the ramping speed of hydro resources like the lower Snake River projects, which can change their output by hundreds of megawatts in just a few minutes. Resource and technology options that provide this type of firm ramping capability include the following: simple-cycle natural gas plants such as an LMS100 or frame, reciprocating engines, pumped storage, and batteries. Table 3-160 presents the historical ramps for the lower Snake River projects.

**Table 3-160. Historical Sustained Ramping Capability (aMW) for the Lower Snake River 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 |

### Replacement Resource Options

This section provides an overview of the known major categories of resources with attributes that could be used in a portfolio designed to replace the capability of the lower Snake River projects. The characteristics, benefits, and limitations of these resources are also discussed. As discussed below, no one group or grouping of resources completely replaces the capabilities of the lower Snake River projects. Further, many of the resources considered in this analysis would need to be developed in sizes above known and tested utility-scale quantities. As such, developing a portfolio with attributes that could fully replace the lower Snake River projects would require additional considerations and analysis not addressed in the other MOs.

#### *Solar, Wind, and Batteries*

Combining utility-scale solar, and wind resources with battery technology is one potential resource replacement portfolio that could form an integral part of a comprehensive zero-carbon replacement portfolio. Like the lower Snake River projects, this portfolios is carbon-free. Wind and solar together provide a robust portfolio of zero-carbon energy. Solar, especially during the summer, can provide energy during heavy load hours that follow the general load profile. Solar, however, does not produce energy during the night. Wind, however, can produce energy during both the daytime and nighttime hours. Together, these resources would allow for generation day and night, mitigating the lost firm energy production of the lower Snake River projects. Utility-scale batteries would replace the lost flexibility and ramping capability of the lower Snake River projects. However, the batteries provide an imperfect replacement for the lost capability of the lower Snake River projects because, while batteries can be discharged to provide energy, they also need to be recharged and consume energy on a net basis.

The amount of megawatts needed from the solar, wind, and battery technology zero-carbon portfolio would be significantly above the lost generation from the lower Snake River projects. The annual average output of the lower Snake River projects is approximately 1,000 aMW. On average, the capacity factor for solar is 25 percent and for wind is 32 percent. Thus, for every 100 aMW of installed solar, only around 25 aMW of energy would be produced in an average year. Replacing 1,000 aMW of generation from the lower Snake River projects would take at a minimum 2,536 MW of solar capacity and 1,144 MW of wind capacity. These values do not take into account seasonality. The amount of wind reflects the amount that would be needed to equal the light load hour generation levels of the lower Snake River projects. The solar capacity amount reflects the amount needed to meet the average lower Snake River generation level in the remaining hours. It is assumed that there would be surplus energy at times from the wind and solar that could be used to recharge the batteries so they could be used for providing ramping and reserves.

To provide a similar level of sustained ramping (Table 3-160, above) as the lower Snake River projects, 2,265 MW of batteries would be needed. Additionally, the lower Snake River projects provide 250 MW of operating reserves. This would bring the total to 2,515 MW of batteries needed to replicate the peaking and flexibility of the lower Snake River projects. Developing utility-scale batteries of this size is untested. The largest battery facility in the world is currently 100 MW. The annual cost breakdown for this portfolio is described in Table 3-161.

**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** |

The values stated above are the estimated minimum amounts of installed solar and wind needed to ensure production of sufficient surplus to recharge the batteries. This assumption is untested and additional modeling would need to occur to verify its accuracy. If an additional 770 MW of solar were needed to recharge the batteries to ensure a high probability of reserve power availability, then an additional $111,000,000 of annual costs would be needed. Table 3-162 summarizes the replacement portfolio, including the additional solar, to replace most of the lost generation from the lower Snake River projects attributed from MO3.

**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** |

Another limitation of the wind, solar, and battery portfolio is its inability to provide voltage and inertia[74] benefits. As described above, the lower Snake River projects provide voltage and inertia benefits to the transmission system. Currently, wind, solar, and batteries do not provide the same level of voltage support as an installed generator, though this may change with advancements in technology. Providing inertia benefits from solar and wind resources and battery technology, however, would be more challenging because these facilities do not have the same heavy rotating mass as hydro generators. New technologies that would allow wind, solar, and batteries to mimic the inertia characteristics of synchronous generators have yet to be developed.

***Pump Storage***

Pump storage is another carbon-free source of battery storage that could supply flexibility, ramping, and reserves. Bonneville used the most recent reference plant from the NW Council as a rough estimate for use of a pump-storage resource. For a 2,515 MW pump-storage plant, the annual costs would be $305 million. This presumes that a location could be found that would support such a large volume of pumped storage and that the cost of pump storage is scalable. The actual cost associated with pumped storage is very site- and water-dependent. Further, such large amounts of pumped storage development would have environmental implications as well as potential impacts to cultural resources, especially archaeological resources and traditional cultural properties. The annual costs for pumped storage can appear low as the costs are spread over a 50-year economic life. Additionally, pumped storage would need an energy resource to replace the energy generation of the lower Snake River projects as pumped storage plants consume energy while their ponds are being filled and are, therefore, a net consumer of energy.

***Small Nuclear Reactor***

SMRs (new generation nuclear reactors) are another carbon-free resource option for energy that could potentially provide energy, some flexibility, and firm capacity. Cost estimates were provided by UAMPS based on the Carbon-Free Power Project. Although the resource has not been fully developed, preliminary estimates for a 654 MW unit put the cost of the SMR at around $151 million (2019 dollars) annually. Scaling the size up to the annual generation levels of the lower Snake River projects would put the costs at roughly $231 million (2019 dollars) 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.

to provide ramping capability similar to the lower Snake River projects at this time. If they are not, then ramping capability from another technology (such as batteries) may also be needed.

***Value of Lower Snake River Dam Flexibility***

Bonneville uses the LSR projects to provide generation balancing reserves. The LSR projects are among the big ten projects and are connected to automatic generation control (AGC) which allows them to respond quickly to requested changes. The amount of generation balancing reserves that Bonneville holds at the LSR projects changes by project and by season. To estimate the value of flexibility provided by the LSR projects, Bonneville used rate case values from the BP-20 rate case and parsing out the values based upon how many reserves are held at the LSR projects. Table 3-163 summarizes the results.

**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 |

***Value of Lower Snake River Dam Ramping Capability***

The LSR projects can be uniquely operated during certain times of the year to help maintain system reliability by having their generation backed down to very low, or even zero generation levels at night when demand is low, and then ramped up during the day to meet daytime peaks. This ability may be less obvious when looking at only Heavy Load and Light Load Hour generation. To assess the value associated with ramping, Bonneville looked back at actual generation to derive a sustained peak value (6 peak hours per weekday). This value is representative of the average of the super peak hours when the highest generation is needed. This super peak value is used to represent the sustained peak generation over an extended period of a few hours. Once the super peak value was derived from historic actual generation, it was then compared to the minimum generation required of those projects, to derive how much the LSR can ramp from minimum generation to a sustained peak. To derive the value associated with this ramping, Bonneville calculated, the difference between graveyard prices and super peak prices using information from the BP-20 rate case studies and the 2030 LT Forecast models from Aurora. These prices in combination with the ramping amount combine to derive a value. Table 3-164 below summarizes the results.

**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 |

**Coal Retirement Considerations**

The base case analysis described above assumed that current existing levels of coal would remain in service to achieve the No Action Alternative level of LOLP of 6.6 percent. Under future conditions with limited or no coal generation capacity, restoring LOLP to 6.6 percent—the No Action Alternative LOLP level—requires a substantially larger portfolio of new resources. To meet that level, an additional 1,350 MW to 4,150 MW of zero-carbon replacement resources would be needed above and beyond the zero-carbon resources Bonneville (or the region) procured to return the region to the No Action Alternative LOLP of 6.6 under MO3 in the base case. Table 3-165 summarizes these values.

As previously described, the urgency of regional resource adequacy was made clear in in the 2019 E3 report. In light of this context, eliminating generation of the lower Snake River projects would exacerbate the existing resource adequacy issue by retiring significantly more generation from the system at the same time that the region is struggling to replace coal generation already scheduled for retirement.

**Table 3-165. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 3 Relative to the No 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 |

Note: The replacement resources for the No Action Alternative include demand-response, wind, and solar; for MO3, the analysis additionally includes storage technology (e.g., batteries, pumped storage). The incremental resource builds under the more limited coal capacity or no coal capacity are additive with the resource builds under the base case.

**Related Studies**

In March 2018, the NW Energy Coalition (NWEC) released a report prepared by Energy Strategies Inc. that evaluated the effects of replacing the LSR projects' output using a combination of demand response, conservation measures, utility-scale solar and wind generation, and natural gas. The basic approach of this study was similar to that of the EIS for identifying both a potential least-cost and a potential zero-carbon portfolio for replacing lost hydropower. The NWEC study results were considered in testing the outputs of the EIS analysis. Compared to the CRSO EIS, the scope of the NWEC study is much narrower, making direct comparisons to the CRSO EIS difficult. The study uses older load data and natural gas price forecasts, has lower estimates for transmission-related costs, and therefore underestimates impacts to Bonneville ratepayers. Appendix H compares the NWEC report and the EIS analysis in more detail.

In July 2019, ECONorthwest published a report commissioned by Vulcan, Inc. that adopted NWEC's 2018 power replacement study in an effort to examine various tradeoffs associated with dam removal on the lower Snake River. Compared to the findings in the CRSO EIS, the most significant difference associated with the Vulcan study stems from the inclusion of quantified "non-use" values associated with the Columbia River and differences in cost estimates associated with irrigation system modifications. Similar to the NWEC study, transmission-related costs appear to be considerably underestimated.

In December 2019, Northwest River Partners released a report prepared by EnergyGPS Consulting, LLC (EGPSC), reviewing the above NWEC study. The review points out that the NWEC study relied on load and resource forecasts are now over 3 years old. In large part due to changing regional energy and climate policies, many more coal-plants are slated for retirement since the NWEC study, and EnergyGPS expects that all cost-effective demand response and energy efficiency resources will be used to replace the lost coal generation rather than being available to replace lost hydropower. Further, the reliance on imports was noted as being too high, the cost of transmission too low, and no penalty associated with increasing reliance on fossil-fuel-based generation. The EnergyGPS study used updated load, resource, and policy information to propose a replacement portfolio for the LSR generation using new renewable resources with battery storage, an adder for transmission costs to integrate the new resources, and an adder for the compliance cost of incremental carbon emissions. This portfolio would cost about $860 million per year or $96/MWh. This cost estimate is in line with the costs identified in the EIS analysis.

## BONNEVILLE'S FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION PLAN COSTS

The summary rate table for MO3 includes an estimate of $281 million in annual costs (adjusted to 2019 dollars) for the Bonneville Fish and Wildlife Program in the Base Case analysis, which is consistent with the No Action Alternative, but excludes the LSRCP. Upon the breaching of the lower Snake River projects, Bonneville would no longer have an obligation to fund the operations and maintenance of the LSRCP, estimated at $34 million annually when adjusted for 2019 dollars, because Bonneville's funding authority is directly tied to the operation of the lower Snake River projects. In so stating, Bonneville also recognizes that there will be transitional needs that would have to be addressed by Bonneville and other funding sources.

As previously discussed, Bonneville Fish and Wildlife Program funding decisions are not being made through the CRSO EIS. However, Bonneville Fish and Wildlife Program costs are included in the EIS to inform a transparent cost analysis for each MO, as discussed in Section 3.19. Future budget adjustments will be made in consultation with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements. In the case of MO3, Bonneville included a range of potential Bonneville Fish and Wildlife Program costs to acknowledge the possibility that MO3 could provide biological benefits to fish and wildlife and that this could, in turn, reduce the need for some offsite mitigation funded by the Bonneville Fish and Wildlife Program. Not including this potential scenario could impact the analysis of the overall costs for MO3, potentially showing higher cost than would ultimately be required. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its Fish and Wildlife program and also acknowledges the uncertainty around both the magnitude of biological benefits and the potential impacts on funding, including the timing of funding decisions. For this reason, potential adjustments to the Bonneville Fish and Wildlife Program, which are estimated to range up to $105 million, are analyzed as part of the Rate Sensitivity analysis.

**EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

**Bonneville Interconnections**

The developers of individual replacement generation resources would have to construct certain transmission facilities (e.g., lines and equipment) to interconnect the resource to the transmission system. Those facilities would result in additional costs, which would vary depending on the location of the resource with respect to the transmission network, size of the individual project, and other factors.

Bonneville, for its part of the resource interconnection, would also have to construct additional transmission facilities at the point of interconnection in order to interconnect the new resource to the transmission system. The Bonneville portion of the interconnection would require equipment such as bulk transformers, circuit breakers, and other substation equipment, which may require the expansion of multiple existing substations. The addition of transmission substation infrastructure to accommodate interconnections can take several years to plan, permit, and construct, especially at those substations requiring expansion beyond the current footprint.

Based on the assumptions described above, Bonneville identified approximately $72 million in direct costs on the transmission network (which the customer would fund and Bonneville would repay in transmission credits) necessary to accommodate the interconnections for the least-cost portfolio under MO3. Bonneville identified $150 million in direct costs on the transmission network necessary to accommodate the interconnection for the zero-carbon portfolio under MO3. These would cost $9.1 million to $13 million when annualized. The costs identified here include land and substation equipment.

As discussed above under *Lower Snake River Replacement* in this section, a replacement portfolio containing a mix of batteries and wind generation could replace the attributes of the lower Snake River projects that would be breached under MO3. Depending upon the location of the wind generation and battery placement, additional direct network interconnection costs would be required.

**Bonneville Transmission System Reliability and Operations**

Under M03, assuming replacement resources under either of the two replacement resource portfolios are online by the time the changes in hydropower generation are implemented, it is unlikely that any additional transmission reinforcements beyond those described below are necessary. However, the timing of bringing replacement resources online may affect the timing of the existing transmission reinforcements that have been identified.

Prior to evaluating the effects of a potential breach of Ice Harbor Dam under MO3, Bonneville had identified the need for a transmission reinforcement project just beyond the 10-year planning horizon to maintain reliable load service to the Tri-Cities area and to support transmission system reliability. The base need for the project would arise independent of removal of the generation at Ice Harbor. The timing of the reinforcement, however, is very dependent upon when Ice Harbor generation might be removed. The generation at Ice Harbor is embedded, or co-located, with the loads in the Tri-Cities, making it a critical source of power to serve the Tri-Cities area load, particularly during peak summer load conditions. Due to current limits on transmission infrastructure into the Tri-Cities area, an outage of one of the transmission lines connecting the Tri-Cities area to the main transmission grid substantially limits the amount of energy that can be delivered to the Tri-Cities load. During such outages, generation from Ice Harbor ensures reliable service to the Tri-Cities load. The generation at Ice Harbor also allows Bonneville to take lines out of service for planned maintenance and other operational reasons without affecting reliable service to the Tri-Cities area. The inability to take lines out of service for maintenance and to respond to operational constraints, such as the loss of a transmission line, could increase risk to transmission system reliability and result in loss of load to the Tri-Cities area.

Under MO3, the loss of hydropower generation at Ice Harbor would require that the reinforcement project be in place prior to breaching of the dams, which may be sooner than would be required under the No Action Alternative. If the dams were breached prior to completion of the reinforcements, the Tri-Cities area would be vulnerable to the potential loss of load during congestion. The scope of the likely reinforcement would include a new substation, a new 20-mile-long transmission line, and the expansion of an existing substation near the Tri-Cities. The reinforcement project would cost approximately $94 million in direct costs to construct. It should be noted that these types of transmission system reinforcements typically take many years to plan, permit, and construct. Any transmission reinforcement project would likely result in additional, but currently unknown, impacts to environmental and cultural resources, which may include vegetation, wildlife habitat, archeological resources, and traditional cultural properties. Additional environmental and cultural impacts from transmission reinforcement projects would be identified and analyzed by Bonneville during future site-specific environmental review, including NEPA and permitting processes.

If the replacement resources assumed for MO3 were not in place when the changes in hydropower generation were implemented, there could be a period when the transmission system would need to operate at reduced operating limits in some locations until additional resources were brought online (or transmission infrastructure were constructed). In addition to the loss of hydropower from the Snake River projects, the reduction in hydropower at the lower Columbia River projects (McNary, John Day, The Dalles, and Bonneville) in the summer months (except for August under this alternative) would likely result in fewer generators being online and available to maintain an acceptable voltage profile and provide dynamic support for the larger transmission system. If too few generators are online, the operating limits of the transmission system may need to be lowered to avoid equipment damage and potential uncontrolled load loss. Operating at lower operating limits could result in increased congestion and a re-deployment of resources throughout the Western Interconnection to meet the required load demands at that time. This congestion goes beyond the regional transmission congestion levels that are reported under the *Regional Transmission System Congestion Effects* section below.

Limitations around voltage and dynamic response would be aggravated under scenarios with reduced coal generation, as coal generation plants provide similar support to the system as hydropower generators. Renewable resources currently neither have the technology nor the requirement to provide comparable dynamic and frequency support. Technology under development and implementation of additional requirements may be needed under a zero-carbon resource portfolio in order to have certainty that replacement solar resources will be able to provide adequate reactive and dynamic support to respond to larger transmission disturbances. Again, it can take several years to plan, permit, and construct these transmission reinforcements should they be needed.

If a renewable resource and battery technology replacement portfolio is used, the location of the batteries provides different benefits. If batteries are co-located with new or existing renewable resource interconnections, the ability of the resource to provide energy, with certainty, at peak load would increase. Other concerns would still need to be addressed, such as what transmission and resource(s) arrangements to provide battery charging when generation from the solar or wind resource is unable to do so. Generation from the FCRPS hydro projects could provide alternative charging, which would help shape FCRPS generation (incremental storage to the remaining CRSO projects).

Batteries sited at the current transmission stations interconnecting the lower Snake River projects could reduce interconnection facilities and costs required to accommodate the batteries under this resource replacement portfolio. However, there may be limitations at existing transmission substations preventing expansion to accommodate the interconnection of battery storage capacity. There is some concern that the capacity at interconnection facilities may still be "consumed" if synchronous condensing capability is used at the powerhouses of the lower Snake River projects.

If the batteries were sited at load centers, there could be a transmission system reliability benefit. In particular, it would be very desirable to have some batteries located within the Tri-Cities load area, as it would eliminate or delay the difficulties with the timing of the transmission reinforcements identified above.

In other major load centers such as Portland and Seattle, the addition of batteries could substantially reduce transmission loading under peak conditions, providing additional benefits to the transmission system.

**Regional Transmission System Congestion Effects**

The fluctuation in the number of congestion hours caused by MO3 for either replacement resource portfolio relative to the No Action Alternative would be small in comparison to the fluctuations in congested hours caused by variations between runoff conditions (i.e., differences between high, median, and low runoff conditions).

For the majority of transmission paths, for both replacement resource portfolios in low runoff conditions, congested hours would have little to no change (less than 30 hours) under MO3 compared to the No Action Alternative.

In both median and high water runoff conditions, some north-to-south transmission paths would experience a slightly increased number of congested hours compared to the No Action Alternative. The Pacific DC Intertie has the greatest increase in congestion hours of the north-to-south paths, increasing congestion by over 365 additional hours compared to the No Action Alternative during high water runoff years as more power is exported out of the region. During these times of increased congestion, the amount of additional power that could be exported outside of the Northwest via the Pacific DC Intertie to meet power needs could be limited by the congestion.

With less hydropower generation (particularly without the lower Snake River CRS projects) under MO3, however, the west-to-east lines, including those that are the most congested under the No Action Alternative, would experience fewer congested hours under high runoff conditions. The greatest decrease would be along the Hemingway to Summer Lake transmisison path, as less hydropower generation would be available to be sent east. The Hemingway to Summer Lake transmission path could have a decrease in congestion by about 150 and 498 hours, depending on replacement resource portfolio, during a high water runoff year.

Overall, changes in the patterns of CRS generation under MO3 would have a relatively small or minor impact on congestion for most Pacific Northwest transmission paths and a minor to moderate increase in congestion hours for some north-to-south paths, particularly the Pacific

DC Intertie during median and high runoff conditions. There would be a minor to moderate improvement in congestion hours on some west-to-east lines, particularly the Hemingway to Summer Lake transmission path.

If the assumed replacement resources are not in place when the changes in hydropower generation and breach of the lower Snake River projects are implemented under this alternative, the number of hours and location of congestion would change depending on which replacement resources were online at the time.

Under a renewable resource and battery technology replacement portfolio, transmission congestion patterns could shift depending upon the location of the wind generation and battery placement.

Under a limited to no coal future, if a net reduction in resource availability also occurred in the Pacific Northwest or other regions or both due to additional coal retirements, then the effects of CRS hydropower reductions with or without replacement resources could shift from what is reported above.

Detailed graphs depicting the number of hours of congestion along the individual flow paths under different water years appear in Appendix H.

**ELECTRICITY RATE PRESSURE**

**Bonneville Wholesale Power Rates**

Under MO3, there would be upward wholesale power rate pressure for all portfolios due to the large decrease in hydropower generation. The highest upward rate pressure would occur under the zero-carbon portfolio that would result in the highest average wholesale rates in the Bonneville-financed replacement resources portfolio. [75]

**Bonneville Finances**

Table 3-166 presents the estimated rate pressure effects on Bonneville's wholesale power rate under MO3 based on changes in the amount of hydropower generated and the secondary (market) sales. In MO3, Bonneville would realize some cost savings related to the cost of operations and maintenance at the lower Snake River projects. The annualized cost of structural measures associated with MO3 would total $17 million (2019 dollars), but this is offset by $7 million in reduced capital expenses for the breached dams, in addition to the $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.

Together with the $34 million in lower F&W Program expenses, net cost savings is $71 million per year in 2019 dollars. However, these savings are more than offset by cost pressures associated with replacement resource builds and effects on the power market and secondary revenues. Should the upward rate pressure lead to rate increases (i.e., assuming Bonneville or other entities were unable to balance the additional costs), Bonneville wholesale power rates could range from $3.31 per MWh to $6.67 per MWh (2019 dollars) higher depending on the replacement portfolio (e.g., least-cost or zero-carbon) and financing portfolio (e.g., Bonneville- or region-financed). This represents an upward rate pressure between 9.6 and 19.3 percent in the average Bonneville wholesale power rate compared to the No Action Alternative.

In the scenarios with limited or no coal generation in the region, these upward rate pressures would likely be substantially higher. Appendix H, *Power and Transmission*, presents a full breakdown of sensitivity of results to coal-closure scenarios and structural measure costs as well as the potential effects on wholesale power rates.

Summary results for Bonneville's wholesale power rate pressure analysis in the Bonneville Finances scenario are presented in the first section of Table 3-166. As discussed in Section 3.7.3.1, the second section of Table 3-166 provides the cost pressure to the region of MO3 in light of potential carbon compliance and accelerated coal retirements.

Results for the Region Finances scenario are presented in Table 3-167. It is important to note that the wholesale power rates presented in this table are from the perspective of Bonneville's wholesale power rate. In the Region Finances scenario, replacement resource costs are assumed to be recovered by regional utilities (not Bonneville), and therefore, are excluded from Bonneville's power rates. The socioeconomic chapter shows the geographic distribution of rate impacts down to retail rates in both scenarios. As such, the costs which are missing from Bonneville rates in the Region Finances scenario in this section are included in the retail rate impacts of the consortium of public customers assumed to finance the resource replacement. The summary analysis focuses on the Bonneville Finances scenario, because this includes most of the relevant costs affecting its customer base, while the Region Finances scenario excludes real costs affecting regional rates which are not explicitly included in Bonneville's wholesale power rate.

### *Bonneville Finances*

**Table 3-166. Average Bonneville Wholesale Power Rate ($/MWh) under Multiple Objective 3, for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures 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 | |

Note: Line 14 represent the approximate range in fixed costs for replacement resources for the more limited coal scenario and the no coal scenario. Additional changes in value, denoted by line 15, would occur from changes in market prices, changes in technology, and many other factors. Because the retirement of coal plants in the region will change the utility landscape far from the current condition, there is not enough information available to extrapolate from today's information. Base rate includes Colville settlement payment, which has a 2 to 5 percent increase from the No Action Alternative.

<u>Base Case Analysis</u>

Base rate pressures range from 9.6 percent to 19.3 percent depending on the resource portfolio, with a higher rate pressure associated with the zero-carbon resource replacement. In the zero-carbon scenario, annual average cost pressure is $381 million per year (2019 dollars), equate to a 18.6 percent upward pressure, and a small decrease in preference customer loads leading to a 0.7 percent upward pressure on power rates, resulting in an overall upward rate pressures of 19.3percent. Rate pressure includes a reduction in O&M expenses for lower Snake River projects and cost savings associated with the LSRCP, which are more than offset by large capital costs to finance and maintain the solar resource replacement, structural measure debt financing, lower net secondary sales revenues, and higher energy efficiency expenses associated with the demand response program. In the conventional least-cost scenario, the $199 million in upward rate pressure, which results in an upward rate pressure of 9.6percent, is associated with a reduction in O&M expenses for lower Snake River projects and cost savings associated with the LSRCP, which are more than offset by large capital costs to finance and maintain the gas turbine resource replacement, structural measure debt financing, and lower net secondary sales revenues. In addition to these cost pressures, loads in the least-cost scenario are virtually flat compared to the No Action Alternative, contributing to a 0.1 percent downward pressure on power rates. Overall, the base rate pressure is 6.0 percent.

Rate Sensitivity Analysis

Rate sensitivities are presented in Table 3-166, lines 5 through 11 to provide quantitative estimates relative to the additional sensitivity analyses described in Section 3.7.3.1.

Line 5 describes potential additional cost reductions to Bonneville's Fish and Wildlife program that could be achieved above the reduction assumed in the base case rates analysis. These reductions reflect lower costs associated with fish and wildlife mitigation efforts due to a combination of the loss of the lower Snake River dams, higher spill requirements, and lower overall system generation. *See* Section 3.7.3.5 ("Bonneville's Fish And Wildlife Program And Lower Snake River Compensation Plan Costs.")

The Integration Services sensitivity (line 6) under MO3 evaluates the cost of replacing the full capability of  the lower Snake River projects. As described above, the base case rates analysis estimates the zero-carbon resource costs needed to return the region to the No Action Alternative LOLP level (2,550 MW of solar generation), along with returning a portion of the lost flexibility of the lower Snake River projects (1,275 MW of battery technology). The costs to fully replace the lower Snake River project capability with zero carbon resources is discussed in section 3.7.3.5 ("Lower Snake River Replacement (Used In Rate Sensitivity Analysis)").  The Integration Services sensitivity takes these cost estimates and applies them to the base case rates analysis.

For the zero-carbon portfolio, the full capability replacement costs for the LSR is estimated to cost $966 million per year, which results in a net incremental cost of $527 million above the base case analysis.[76]

For the conventional least cost portfolio, no incremental replacement resources are needed 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.

portfolio would also return some of the l Cost contingency and balancing reserves relative to the base rate analysis, restoring contingency and balancing revenues by $5.3 million.

Resource financing assumptions (line 7), which address alternative amortization periods to the 30 years assumed in base rates, show upward cost pressure of $90 million per year in the zero-carbon portfolio and $24 million per year in the least-cost scenario.

Resource cost uncertainties (line 8) could add up to $12 million in additional cost pressure in the zero-carbon portfolio and add up to $7 million in additional cost pressure in the least-cost portfolio.

Demand response costs (line 9) could be lower than assumed in the $20 million/year in base rates; a potential cost savings of $12 million per year is shown on the low end for this sensitivity. However, to account for the challenges to scaling up demand response programs in Bonneville’s service territory, this portion of the resource portfolio could be as high as $52 million per year higher than assumed in base rates if up to 50 percent of the program needed to be replaced with a 300MW solar and battery resource instead.

OMP costs (line 10) associated with oversupply events could be $1 million per year lower in the zero-carbon portfolio and up to $5 million in the least-cost portfolio.

For the integration services sensitivities under MO3, the values reflect a combination of the change to resource flexibility and reserve carrying capability. To value flexibility associated with the lower Snake River projects, the study incorporated two changes relative to the LOLP analysis in base rates: (1) the addition of batteries for storage tied to the 2,250 MW solar project, and (2) a reduction in generation inputs revenues of $21 million as a proxy for the value of lost flexibility. [77]

The flexibility sensitivity incorporates first a lower replacement resource cost assumption for the zero-carbon resource portfolio. The least-cost portfolio LOLP studies showed that solar installations without accompanying batteries for storage would have $300 million in annualized capital costs over 30 years, which does not value the unique flexibility and balancing characteristics of the lower Snake River projects. The portfolio selected for base rates added batteries to 50 percent of the installed capacity and includes these increased costs into the revenue requirement for a total annual cost of $418 million. The difference between these two portfolios, establishes a lower bound for the zero-carbon portfolio with a reduction from base rates of a $129 million.

Because the solar installation without flexibility and storage is incomplete, additional valuation was necessary for this lower bound estimate. To monetize the value of changes in contingency and generation balancing reserve carrying capability, the sensitivity analysis includes (1) any 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.

balancing needs of replacement resources, and (3) energy shaping benefits from ramping capability of the lower Snake River projects into super-peak periods.

Generation inputs revenues in base rates were assumed to be $21 million lower than the No Action Alternative. To fine-tune this proxy, the sensitivity analysis looked at the lower Snake River projects' contribution to reserves carried to provide contingency and balancing services. The lower Snake River projects hold about 20 percent of Bonneville's upward flexibility (increases), 8 percent of its downward flexibility (decreases), and about 5 percent of its operating reserves for the FCRPS.[78] The estimated value of the reserves held at the lower Snake River projects in the No Action Alternative is $15.7 million using BP-20 rates. Therefore, the lower bound values include an assumed cost savings of $5.3 million ($15.7 million less $21 million) for this incremental difference of assumed generation input revenue impacts.[79]

Annual resource integration costs associated with replacement resources under MO3 were calculated using BP-20 operating and generation balancing reserve rates. Estimated annual integration costs for the 2,250MW solar resource replacement under MO3 for the zero-carbon portfolio ranged from $61.7 million to $72.2 million, with the average $66.9 million. This estimate reflects the intermittent characteristics of the carbon-free replacement which requires both contingency and generation balancing reserve services.

The value of lost sustained ramping capability was based upon historical data. Actual generation shaping into the 6-hour super peak period on the lower Snake River projects informed the quantity of super-peak shaping which might reasonably be expected to continue absent breach of the dams. This super-peak quantity was then compared to the minimum generation required of those projects to derive how much the dams can ramp from minimum generation to a sustained peak. To derive the value associated with this ramping, the difference between graveyard prices and super-peak prices was used, which relied on BP-20 rate case studies to estimate a value range. This range is used as an incremental cost not included in base rates for this sensitivity of $2.9 million to $27.2 million, for an average ramping value of $15.1 million. This ramping value is included in the lower-bound sensitivity.

For a high-end sensitivity flexibility costs, Bonneville analyzed the cost of a like-for-like replacement of the lower Snake River projects. As detailed above, this included a combination of solar, batteries, and wind generation sized to reflect the reserves carrying capability of the system, as well as ramping and flexibility to move generation into higher-valued periods. This resulted in an annual average cost of $966 million per year, which is $548 million above the resource capital cost included in base rates. However, because this like-for-like resource 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.

reduction of $21 million is subtracted from the incremental resource cost to produce a high-end sensitivity of $527 million.

Line 6 in Table 3-166 includes the sum of (1) forecast differences in resource replacement costs, (2) forecast changes to generation inputs revenues, (3) forecast changes associated with integration costs, and (4) forecast changes associated with the incremental value of ramping capability to produce a range of $-41.3 million to $527 million for the zero-carbon portfolio, and $-5.3 million for the conventional portfolio.[80]

<u>Other Regional Cost Pressure</u>

Cost pressures to regional utilities, which do not necessarily impact Bonneville's wholesale power rates, but could in the future, are presented in lines 13 and 14. Effects associated with regional carbon compliance laws are unknown, pending current legislation in Oregon and Washington as discussed in Section 3.7.3.1. If binding estimates effective in the future are enforced to the resource portfolio in MO3, regional utilities could face cost pressure relative to the No Action Alternative of $34 to 168 million per year. In the conventional least-cost scenario, carbon enforcement costs could range between $109 and $623 million per year.

As described in Sections 3.8.3.1, Availability of Coal Resources subsection, and 3.8.3.2, Effects on Power System Reliability subsection, regional utilities would need to add 8,800 MW of additional zero-carbon resources in the limited coal capacity scenario and 28,000 MW of additional zero-carbon resources in the no coal scenario to maintain regional LOLP at No Action Alternative levels (6.6 percent). See Table 3-166. Lines 14 and 15 estimate the incremental zero-carbon resources costs needed by the region to maintain the No Action Alternative LOLP of at least 6.6 percent under MO3 in light of a limited or no coal assumption. An "incremental zero-carbon resource cost" occurs if the combination of (1) the resources Bonneville or the region is expected to acquire under the MO, plus (2) 8,800 MW (under the limited coal scenario) or 28,000 MW (under the no coal scenario), is less than the total amount of zero-carbon resources needed to return the region to the No Action Alternative LOLP of 6.6 percent.

For the limited coal capacity scenario under MO3, a minimum of 13,000 MW of zero-carbon resources would need to be added to maintain regional LOLP at the No Action Alternative level of 6.6 percent. Bonneville or the region is expected to acquire 2,850 MW of zero-carbon resources under MO3 in the base case. Adding 2,850 MW to 8,800 MW is *less than* the minimum 13,000 MW. The region would need to acquire an additional 1,350 MW of zero-carbon resources to return regional LOLP to the No Action Alternative level of 6.6 percent. The incremental cost to the region of those additional resources is estimated to be $82 million per year.

For the no coal capacity scenario under MO3, a minimum of 35,000 MW of zero-carbon 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.

6.6 percent. Bonneville or the region is expected to acquire 2,850 MW of zero-carbon resources under MO4 in the base case. Adding 2,850 MW to 28,000 MW is *less than* the minimum 35,000 MW. The region would need to acquire an additional 4,150 MW of zero-carbon resources to return regional LOLP to the No Action Alternative of 6.6 percent. The incremental cost to the region of acquiring those resources is estimated to be $371 million a year.

***Region Finances***

Results for the region finances scenario are presented in Table 3-167. It is important to note the rate pressures in this table are from the perspective of Bonneville's wholesale power rates. In the Region Finances scenario, replacement resource costs are excluded from Bonneville's wholesale rate, with those costs collected from rates charged by other entities in the region. The costs of replacement resources would be ultimately paid by the customers of utilities that would be receiving less power from Bonneville. The Socioeconomic section below shows the geographic distribution of rate impacts down to retail rates in both scenarios, so that these costs which are not in Bonneville rates in the Region Finances scenario are included in retail rate impacts of the consortium of public customers assumed to finance the resource replacement.

**Table 3-167. Average Bonneville Wholesale Power Rate ($/MWh), for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures 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 | $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%** |

**Market Prices**

Under MO3, average market prices would increase compared to the No Action Alternative. With the conventional least-cost portfolio, the expected average market price would be $19.87 per MWh, an increase of $0.45 per MWh or 2.3 percent compared to the No Action Alternative. With the zero-carbon portfolio, the expected average market price would be $19.73 per MWh, an increase of $0.32 per MWh or 1.6 percent compared to the No Action Alternative. Figure 3-185 shows the average market price and average CRS hydropower generation by month under the least-cost portfolio.

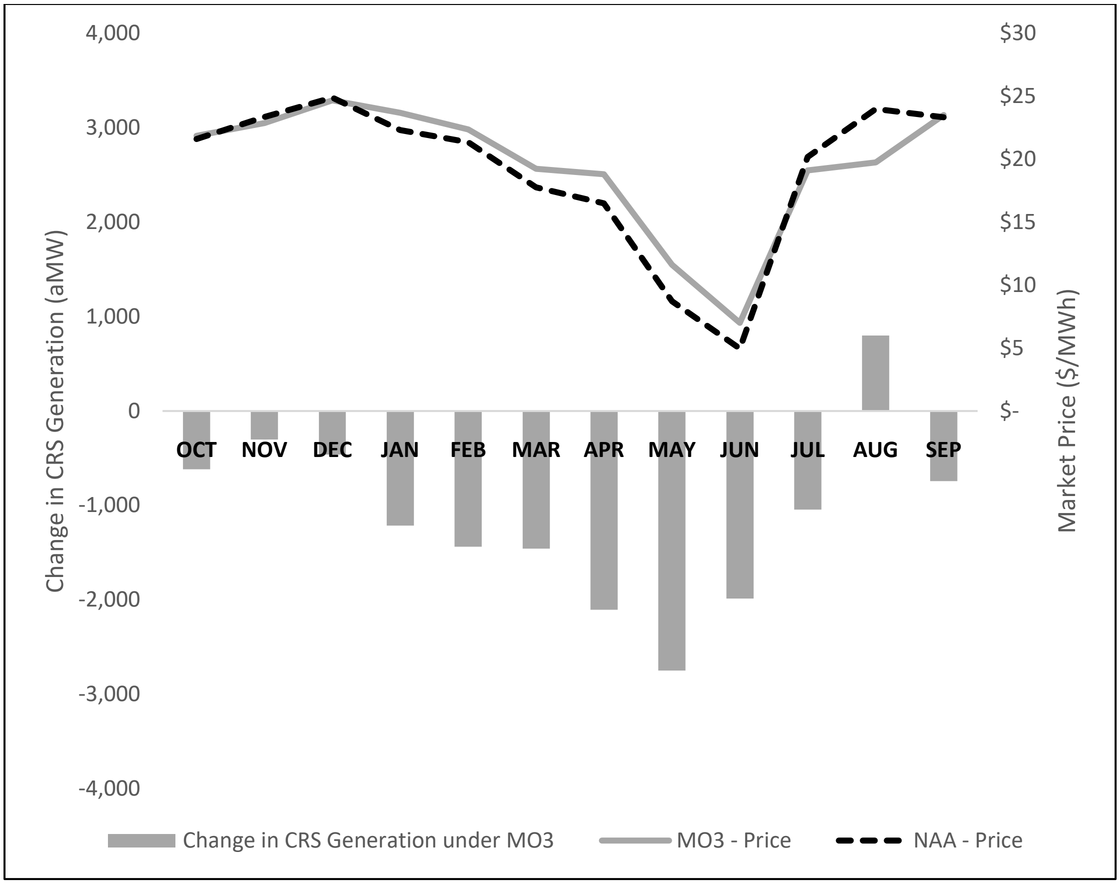


**Figure 3-185. Monthly Columbia River System Generation (aMW) and Market Price ($/MWh)**

Note: The right axis is the market price ($/MWh). The left axis is generation from the CRS projects by month (aMW).

Source: Power Analysis

### Bonneville Wholesale Transmission Rate Pressure

Increased capital costs (between about $167 million and $243 million of direct costs, depending on resource replacement portfolio) associated with the interconnections and a reinforcement project combined with the changes in short- and long-term sales and market pricing would result in an upward transmission rate pressure. Upward transmission rate pressures would range from 1.3 percent annually (11 percent over an 8-year period) for the least-cost portfolio and 1.5 percent annually (13 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 rate pressures would be from 0.60 to 3.2 percent.

### Retail Rate Effects

The retail rate that end users pay to their individual utilities for electricity would experience upward rate pressure under MO3 compared to the No Action Alternative. Should the upward rate pressure lead to increases in rates, the average retail rates under MO3 would range from 10.36 cents per kWh to 10.57 cents per kWh for residential end users depending on the replacement resource portfolio. The rates across portfolios were also similar between portfolios for commercial and industrial end users. On average, counties would experience a 1.6 to 3.6 percent upward rate pressure in residential retail rates depending on the replacement portfolio compared to the No Action Alternative with the zero-carbon portfolio having higher retail rate effects. Customers of utilities receiving power from Bonneville would experience greater upward rate pressure. The largest upward rate pressure across counties would be 15 percent.

**BONNEVILLE FINANCIAL ANALYSIS**

As previously described, the Bonneville financial analysis considers the effects of the MOs on future cash flows over a 30-year financing period for potential replacement resources. For MO3, the discounted NPV of the cash flow effects under each resource replacement portfolio is described in Table 3-168 below. This NPV analysis is Bonneville specific and does not capture wider societal impacts. This NPV analysis uses a risk adjusted discount rate of 7.9 percent and a 30-year timeframe.

The sensitivities in this analysis are described in the Power Rates section, above.

**Table 3-168. Bonneville Financial Analysis Results (in Millions $2019)**

| | MO3 | |
|---|---|---|
| **Analysis Type** | **Zero Carbon** | **Conventional Least-Cost** |
| Power | -$4,610 | -$1,866 |
| Transmission | -$221 | -$171 |
| **Total Base Impact – Bonneville** | **-$4,830** | **-$2,037** |

**DEBT OUTSTANDING ON THE LOWER SNAKE RIVER DAMS**

Bonneville manages its debt as a single portfolio and makes choices about debt repayment based on its financial strategies. For instance, since 2002, Bonneville has worked with Energy Northwest (EN) to refinance EN's debt as it came due which then allowed Bonneville to accelerate the repayment of Treasury bonds, to extend access to limited Treasury borrowing authority, or to reduce interest costs by accelerating the repayment of higher interest rate Congressional appropriations. In these cases, it can be said that significant non-Federal debt is indirectly supporting Federal generation assets. Identifying the amount of outstanding debt is further complicated because the source of financing is not associated with specific capital investments, with the exception of some Congressional appropriations or Transmission Services' lease financing program. Because of this, it is not possible to precisely determine the amount of debt outstanding that is associated with the lower Snake River projects or the associated hatchery facilities of the LSRCP.

However, while it is not possible to definitively identify the amount of debt outstanding, it can be estimated using the debt to asset ratio for Bonneville's Power Services. The debt to asset ratio compares the total amount of debt associated with Bonneville's business units with its revenue generating assets. At the end of FY 2019, the Power Services' ratio was 86.6 percent. This ratio is arguably too low for this purpose because of a change in FY 2019 of the accounting treatment for the future decommissioning costs of the Columbia Generating Station (CGS) nuclear power plant that increased the value of the non-Federal generation asset in the equation. The value of the decommissioning cost is the present value of a future cost that will be funded by cash contributions to a trust fund and earnings on the fund, not by the issuance of debt. Adjusting for this change produces a ratio of 93.64 percent. At the end of FY 2019, Bonneville estimates that the lower Snake River projects had a net investment value of $1.2 billion. If the LSRCP facilities are included in the total, the net investment value is $1.4 billion. Using the two debt to asset ratios and the possible net investment values, the portion of Bonneville outstanding debt for these assets ranges from $1.0 billion to $1.3 billion (Table 3-169).

**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 |

**SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

**Social Welfare Effects**

This social welfare analysis employs both the market price and production cost methods based on the base case for this analysis, assuming no additional coal plant retirements. Section 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*, describes the differences between these two methods. Table 3-170 presents the market value of the reduction in Pacific Northwest hydropower generation under MO3 as compared with the No Action Alternative. Based on the market price method, the average annual economic effect due to decreases in hydropower generation under MO3 is a $150 million cost. If these social welfare effects persist over a 50-year timeframe, the present value cost would be $4.2 billion.

**Table 3-170. Average Annual Social Welfare Effect of Multiple Objective 3 Based on the 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 |

Table 3-171 evaluates the social welfare effects of MO3 based on the additional costs of adding enough new resource capacity to the system to meet power demand given the reduction in hydropower generation described in Table 3-159,. Based on this approach, the social welfare effects of MO3 range from an average annual cost of $270 million (assuming a least-cost replacement resource portfolio) to $540 million (assuming a zero-carbon replacement resource portfolio). If these social welfare effects persist over a 50-year timeframe, the present value costs would be $7.4 billion to $15 billion.

**Table 3-171. Average Annual Social Welfare Effect of Multiple Objective 3 Based on the 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 |

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
1/ Negative values in the table represent an increase (net cost) in the cost of producing power.

### Regional Economic Effects

Estimated average residential retail electricity rates would experience upward rate pressure under MO3 with increases up to 3.6 percent in certain counties across the zero-carbon portfolios and 1.6 percent for the least-cost portfolios. The highest upward pressure could occur for industrial customers with a maximum increase of 29 percent in some counties for industrial end users. These retail rate pressures could negatively affect residential, commercial, and industrial end users due to the increase in spending on electricity relative to the No Action Alternative.

### Residential Effects

Examining potential upward residential retail rate pressure on a geographic basis, the effects of MO3 would negatively affect residential end users across the Pacific Northwest. Many residential end users would experience average upward rate pressure greater than 5 percent relative to the No Action Alternative—much higher than historical year-to-year rate changes. The upward residential rate pressure under MO3 would range as high as 15 percent for certain counties, with average changes above 1.5 percent for all portfolios and financing assumptions. Some utilities that do not purchase power from Bonneville could be largely isolated from the higher rate effects; however, MO3 could result in higher regional total production costs and higher market prices generating adverse rate effects on utilities that do not purchase power from Bonneville.

Under MO3, the largest residential rate pressure effects would occur in urban areas that are not adjacent to metropolitan areas. In these urban non-metropolitan areas under the zero-carbon portfolio, average upward rate pressure effects of 3.0 to 4.5 percent would occur, depending on the financing portfolio. Rural and smaller areas under MO3 would experience smaller rate pressure increases relative to the No Action Alternative ranging from 0.8 to 3.4 percent, depending on the portfolio. Table 3-172 presents the average rate increase by CRSO region. Under MO3, Region D would experience the highest average residential rate pressure increases ranging from 2.4 to 5.0 percent, depending on the portfolio. Region A would also experience higher rate increases ranging from 1.6 to 4.6 percent, depending on the portfolio.

**Table 3-172. Average Residential Retail Rate Pressure Effect of Multiple Objective 3 by Columbia River System Operations Region**

| | Bonneville Finances | | Region Finances | |
|---|---|---|---|---|
| **CRSO Region** | **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% |

Figure 3-186 shows potential residential rate pressure effects under MO3 relative to the No Action Alternative. Negative effects (i.e., upward rate pressure) would occur across the region with multiple counties experiencing small changes, especially in southwestern Idaho and Montana. The highest effects would occur in a zero-carbon Bonneville-financed portfolio.

The upward retail rate pressure would be constant after 2030. Considerable uncertainty surrounds load and rate pressures over time; however, the changes under MO3 would be expected to extend similarly adverse effects over the long term for end user retail rates (Table 3-173).

To the extent that the upward rate pressure leads to changes in rates, end users would increase spending on electricity. As a portion of income, residential end users in MO3 could spend between 1.72 and 1.75 percent of their income on electricity—an increase over the No Action Alternative. Averaging across counties, the fraction of income spent on electricity would increase by 0.03 to 0.06 percent for the average household, depending on the portfolio. Cowlitz County, Washington, would experience the largest increase under MO3 compared to the No Action Alternative—an increase of up to 14 percent in the fraction of income (from 1.6 percent of income to 1.9 percent of income) spent on electricity for a household—because customers there would have a relatively low initial rate under the No Action Alternative. The total increase in household spending on electricity across all Pacific Northwest households would be between $92 million and $210 million per year, depending on the portfolio.

Examining average expenditures, under MO3 the average residential end user would spend between $16 and $38 more per year on electricity. The highest effects across the Pacific Northwest would result in up to $130 more spent per year on electricity compared to the No Action Alternative.

Categorizing the number of households by expenditure change shows the differences each financing portfolio would have (Table 3-174). Under a zero-carbon Bonneville-financed portfolio, 21 percent of all households would experience increases greater than 5 percent. Across all portfolios, between 3.1 percent (zero-carbon) and 37 percent (least-cost) of all households would experience a minimal change between 0 and 1 percent relative to the No Action Alternative.

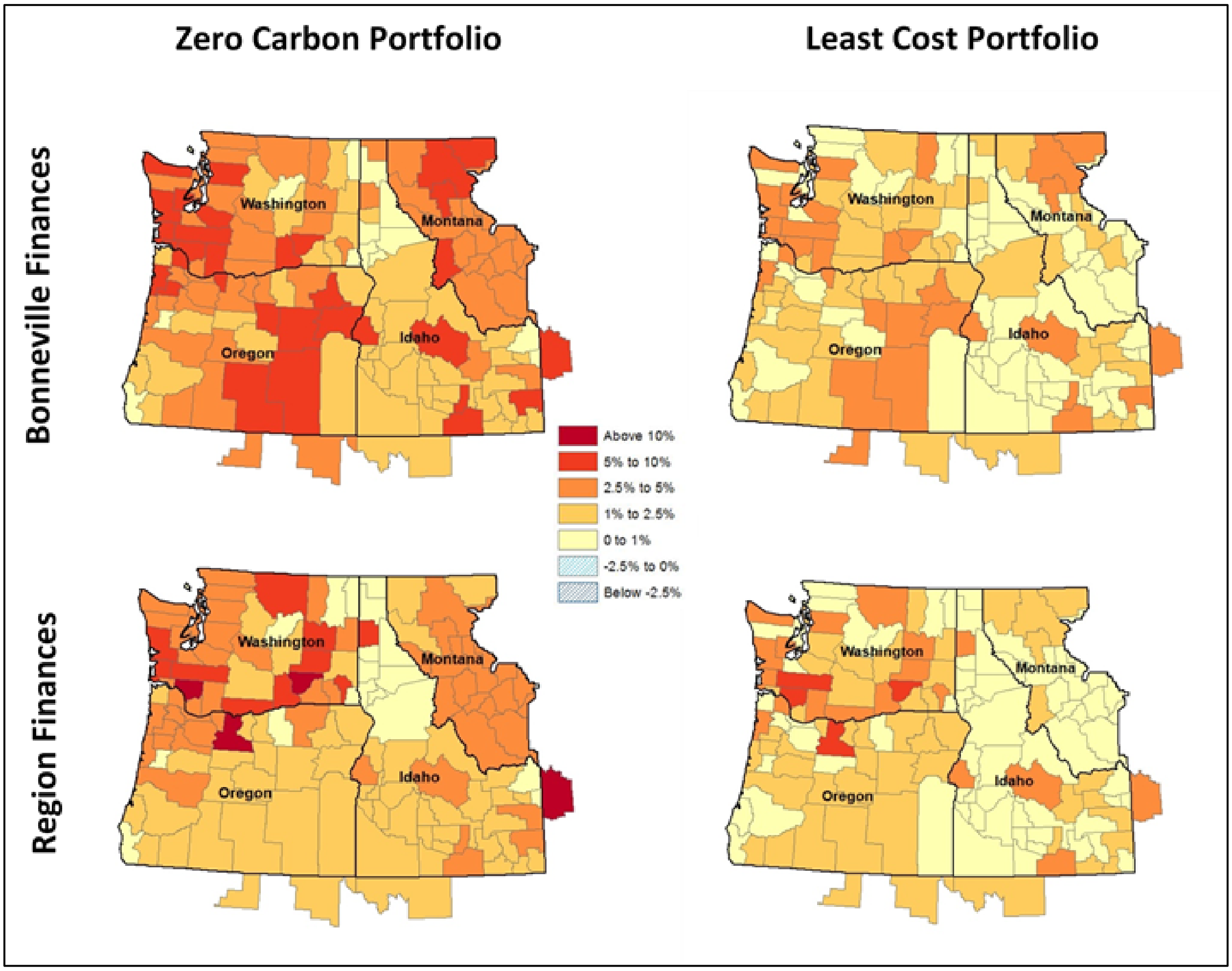


**Figure 3-186. Residential Electricity Rate Pressure Effects by Portfolio for Multiple Objective 3 for the Base Case without Additional Coal Plant Retirements**

**Table 3-173. Average Upward Retail Rate Pressure Effect in 2022 and 2041 under Multiple Objective 3 Relative to the No Action Alternative for the Base Case without Additional Coal 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% |

**Table 3-174. Percentage of Residential End Users Who Experience Changes in Electricity 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% |

Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

Under MO3, expenditures and rates would increase, which would likely result in end users reducing their consumption based on the elasticity of demand (EIA 2014). Many counties that would experience high increases in rates would adjust consumption to reduce their annual expenditures. If the average household reduced consumption, then the costs under MO3 would be reduced by between $16 and $38 per year. In counties where the increase in rates would be highest, due to these higher costs and decreased consumption, households could save up to $130 per year in the most extreme expenditure portfolios to offset some of the increased costs from MO3 (Bonneville-financed zero-carbon portfolio).

This analysis considers how the region wide changes in household spending on electricity would affect demand for other goods and services across the region. That is, the increased spending on electricity may reduce spending on other items, affecting regional economic productivity. This analysis applies IMPLAN to model the increased spending on electricity as a reduction in household income (direct effect) and quantifies the multiplier effects on interrelated economic sectors (indirect and induced effects). This analysis finds that the potential increased cost of household electricity could result in the loss of between $97 million and $230 million in regional output (sales) and between 620 and 1,500 jobs (Table 3-175). The majority of regional economic effects would occur in Washington and Oregon.

**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 |

Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy

### Commercial and Industrial Effects

Commercial and industrial retail rates would also experience upward rate pressure under MO3 across the region compared to the No Action Alternative. The average commercial retail rate under MO3 would experience upward rate pressure of 1.7 to 4.1 percent, depending on the replacement portfolio. Areas with large numbers of commercial entities (King, Pierce, Snohomish, and Multnomah Counties) would continue to have relatively low rates but some, under a Bonneville-financed zero-carbon portfolio (i.e., highest rate effect), would experience upward rate pressure ranging as high as 7.4 percent in Snohomish County, 5.5 percent in Pierce County, 3.8 percent in King County and 4.2 percent in Multnomah County relative to the No Action Alternative. Under the other portfolios the upward pressure effects for all would be smaller.

These upward rate pressures under MO3 could lead to increasing expenditures on electricity for commercial and industrial entities. For commercial end users, the increases would be as high as an average of $960 per year in certain counties that represent an 8.1 percent increase in electricity expenditures. Because industrial end users tend to require large amounts of electricity, the total amount of electricity expenditures would increase by as much as $16,000 per year. The highest percentage increase and dollar increase would not occur in the same county, as the largest percentage change would occur in a county with a lower base rate. The highest percentage increase is a 28 percent increase in electricity expenditures for the highest example of impact on industrial end users, which could cause these end users' demand to fall between 3 and 28 percent, depending on the responsiveness (i.e., elasticity) of the industrial end users to changes in electricity price (EIA 2018a). In addition to lowered electricity use among individual businesses, large rate increases could cause industry to leave the region. Historically, the region had a large aluminum industry, but past increases in electricity prices contributed to those industries shutting down operations in the region, largely in favor of production in other countries (NW Council 2018a). Additional large price increases associated with MO3 could similarly cause electricity-heavy industries to shift production out of the region (Table 3-176).

**Table 3-176. Percentage of Commercial and Industrial End Users Who Experience Changes in 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% |

Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

Under MO3, the upward rate pressure across commercial businesses in the Pacific Northwest would be between $30 million and $70 million per year. This analysis uses the IMPLAN model to quantify the multiplier effects of the change in commercial sector productivity (Table 3-177). The multiplier effects reflect how the increased costs of doing business may affect demand for inputs to production across commercial businesses. This analysis finds that the increased cost of electricity to regional commercial businesses would result in the loss of between $49 million to $120 million in regional output (sales) per year and between 330 to 810 jobs. The majority of regional economic effects would occur Washington and Oregon.

**Table 3-177. Regional Economic Effects from Changes in Commercial Business Spending on 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 |

Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy.

Under MO3, the total increase in spending on electricity across industrial businesses in the Pacific Northwest would be between $100 million and $240 million per year. Similar to the commercial spending analysis, the IMPLAN model is used to quantify the multiplier effects of the change in industrial sector productivity (Table 3-178). This analysis finds that the increased cost pressure of electricity to regional industrial businesses would result in the loss of $170 million and $400 million in regional output (sales) and between 1,000 jobs and 2,700 jobs. Again, the majority of regional economic effects would occur Washington and Oregon.

**Table 3-178. Regional Economic Effects from Changes in Industrial Business Spending on 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 |

Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy.

The effects on commercial and industrial businesses described above are predicated on the region acquiring replacement resources for the reduction in hydropower generation. If the replacement resources are not developed, there would be an increase in risk to power system reliability. Power shortages might occur in about an eighth of the years, with some years experiencing more than one event. These power shortages (blackouts) would have adverse effects on businesses.

**Other Social Effects**

There would be retail rate increases across the region under MO3. These rate increases could lead certain end users to forego normal expenditures, even if only slightly, from the increased energy burden from electricity costs. End users often forgo heating and cooling as well as food purchases due to higher energy bills. MO3 would increase the likelihood of such occurrences relative to the No Action Alternative because household spending on electricity would increase. These effects would be more likely in areas where the highest portion household income goes to electricity bills. These instances of forgoing purchases or inadequately heating or cooling a home would have negative health effects (EIA 2015).

Power reliability would likely return to the No Action level if replacement resources were put online and transmission system reinforcement near the Tri-Cities occurred. Thus, there would likely not be additional safety concerns from a large-scale outage compared to the No Action Alternative, if replacement resources and reinforcement were put online. If either the replacement resources or the transmission system reinforcement did not occur, then there would be reliability issues due to changes in transmission flows. Similarly, if the region (Bonneville or other regional entities) did not acquire additional resources or the new resources were not available before generation from the lower Snake River projects ended, there would be an increased risk of power shortages, which would lead to additional safety concerns. Power shortages (blackouts) would occur more frequently in the winter and would become an issue in the summer as well. Safety concerns include heating and cooling, hospitals and other power-dependent medical support, lighting for safety, and traffic lights.

**SUMMARY OF EFFECTS**

Hydropower generation from the CRS projects would decrease by over 10 percent, or 1,100 aMW (roughly the amount of power consumed by about 900,000 Northwest homes in a year), compared to the No Action Alternative. The FCRPS would lose over 10 percent of the firm power available for long-term firm power sales to preference customers. This decrease in hydropower generation would increase LOLP, meaning there would be an increased chance of substantial power outages.

The reduction in hydropower generation across the Pacific Northwest (a reduction of 1,400 aMW including Federal and non-Federal projects) would result in an average annual economic cost of $150 million when valued at the market price for the foregone power generation. However, the estimated increase in the marginal cost of producing power to meet demand based on additional average annual fixed and variable costs is $270 million to $540 million. If these social welfare effects persist over a 50-year timeframe, the present value cost is up to $15 billion. These values are estimates of the net economic effects from a national societal perspective.

To avoid loss of load events (power outages), large amounts of new capacity would need to be brought online through replacement resources to bring the LOLP of MO3 to the No Action level. Consequently, residential and industrial end users would experience upward retail rate pressure effects of up to 8.1 and 13 percent in their rates and spending on electricity, with 21 percent of households experiencing greater than a 5 percent upward rate pressure under the Bonneville-finance zero-carbon portfolios. Depending on the customer class, the effects expected from upward rate pressure up to 13 percent under MO3 would be adverse and major.

The increased cost of electricity could increase the costs of living and doing business in the Pacific Northwest, resulting in regional economic impacts of $740 million in lost output (sales) and 4,900 jobs.

In the scenarios with limited or no coal generation in the region, the upward rate pressure associated with MO3 would likely be substantially higher. Regional utilities that purchase most or all of their power from Bonneville would experience larger effects than IOUs or other public utilities that do not purchase Bonneville power directly (Table 3-179).

**Table 3-179. Summary of Effects under Multiple Objective 3 without Additional Coal Plant 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 |

| Effect | No Action Alternative[1/] | MO3 Relative to No Action |
| --- | --- | --- |
| Average Bonneville wholesale power rate pressure (base analysis)<br>Potential Range of Bonneville wholesale power rate ($/MWh)<br>Potential range of Bonneville wholesale power rate pressure including rate sensitivities | $34.56 | +8.2% to +19.3%<br>$37.41/MWh to $41.23/MWh<br>4.1% to 50.3% |
| Annualized transmission rate pressure relative to NAA (%) | ——[1/] | +1.3% to +1.5% |
| Average annual social welfare effects ($): 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%<br>(+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%<br>(+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%<br>(+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 |

NOTE: The estimated LOLP effect, and resulting social welfare and rate effects, rely on the best available information regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis. Based on regional energy policy developments and expected coal-plant closures as of 2019, Section 3.7.3.1 discusses the sensitivity of the results of the analysis to these assumptions.

1/ The analysis of the No Action Alternative for these effect categories provides a baseline against which the MOs are compared. Thus, the No Action Alternative results presented in this table describe the baseline magnitude of power and transmission values (e.g., for LOLP and rates) and the MO3 results describe the change relative to the No Action Alternative. A "——" indicates an effect category that is not relevant to the No Action Alternative because it only occurs as a result of implementing the MOs (e.g., the need for new generation and transmission infrastructure and associated costs).

2/ The production cost method for valuing social welfare effects of the MOs relies on information on the fixed and variable costs of replacement generation resources. These costs are not relevant to the No Action Alternative.

#### *3.7.3.6 Multiple Objective Alternative 4*

This section evaluates effects under MO4. Large increases in spring and summer fish passage spill under this alternative would reduce hydropower generation from the CRS projects compared to No Action Alternative. And the addition of up to 2 million acre-feet of water for spring and early summer flow augmentation in drier years would further reduce generation by late summer. Therefore, a large portfolio of replacement resources would be required to bring the LOLP to the No Action Alternative level. The need for replacement resources would result in the highest level of upward rate pressure of any of the MOs compared to the No Action Alternative in the base case without additional coal plant retirements.

**CHANGES IN POWER GENERATION**

Table 3-180 and Figure 3-187 present the generation for the No Action Alternative and MO4 and their differences by month. Overall, generation from the CRS projects would decrease by 1,300 aMW from 8,300 aMW under the No Action Alternative to 7,000 aMW under MO4 (on average, for the 80 historical water conditions). This represents a greater than 15 percent decrease in generation. The decrease in generation from the regional hydropower system, including the non-Federal projects is 1,340 aMW. Although generation would decrease throughout most of the year, the largest decreases would occur from March through the end of August due to the *Spill to 125% TDG* measure. With this level of spill, the eight fish passage projects would mostly be generating only at their minimum generation levels except for a few months in the wettest water years. The *McNary Flow Target* measure would also have a large impact on generation as it increases flows in the spring in the drier years resulting in reduced flows in the late summer and fall. In August in particular, the combination of spill at the fish passage projects and lower flows that impact generation at Grand Coulee and Chief Joseph would combine to reduce generation in a month when heat waves can lead to high loads and reliability challenges.

**Table 3-180 Columbia River System Monthly Generation under Multiple Objective 4 Relative 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%** |

Notes: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding. HYDSIM modeling inadvertently omitted the impact of the *Winter System FRM Space* in December of some years, which would move some generation (0 to 450 MW depending on the year) from January into December. This operation would not change the conclusions of the analysis.

1/ HYDSIM uses a 14-period time step. April and August are split into two half-month periods because these months tend to have substantial natural flow differences between their first and second halves.

Source: HYDSIM modeling results

Figure 3-187 presents the monthly generation of the CRS for MO4 and the No Action Alternative.

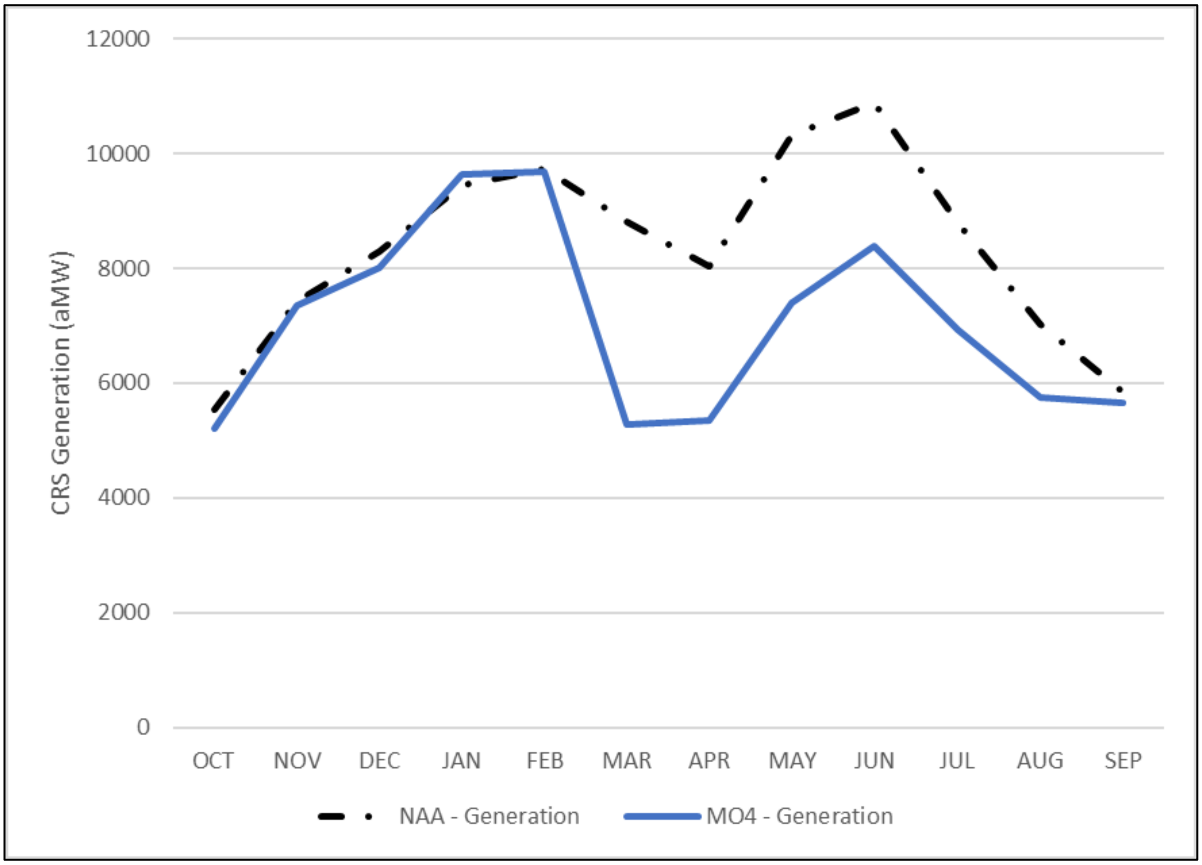


**Figure 3-187. Monthly Hydropower Generation at the Columbia River System Projects, No Action Alternative and Multiple Objective 4, in aMW**

The critical water year generation of the CRS projects would decrease by 14 percent (-890 aMW) and the amount of firm power available for meeting Bonneville's long-term supply obligations would decrease by 870 aMW. The decrease would be largest in June when generation decreases by 30 percent, but the decrease would be most critical in August when generation is already low in the No Action Alternative. The ability of CRS projects to meet peak load and heavy load periods would both decrease by 13 percent (from 11,000 aMW in No Action to 9,400 aMW in MO4 for the peak hours).

Other regional hydropower projects that are located downstream of certain CRS projects (such as the non-Federal mid-Columbia projects) would experience similar trends in hydropower generation to the CRS projects as a result of flow changes but would not be affected by increasing spill to 125% TDG. The regional hydropower system (including these non-CRS projects) under MO4 would generate 12,000 aMW on average. This represents a 10 percent decrease in power generation relative to the No Action Alternative. The CRS projects account for 1,303 aMW of the 1,339-aMW decrease under MO4 due to spill and flow changes.

Based on a qualitative assessment of the alternative, MO4 would substantially decrease the flexibility of operating the CRS projects, primarily in spring and summer due to the increased spill, which would decrease the ability to integrate other renewable resources into the power grid.

**EFFECTS ON POWER SYSTEM RELIABILITY**

The increased spill and flow in spring and summer would lead to an increase in LOLP to 30 percent under MO4, which is 23 percentage points higher than the No Action Alternative. The largest effects on LOLP would result from changes in generation from March to August, and this range includes the summer months when demand for electricity is high. A 30 percent LOLP is roughly the equivalent to a one-in-three likelihood of there being one or more loss of load events in 2022 (e.g., blackouts or emergency power measures such as were implemented in 2001 during the West Coast power crisis), and is more than three times the LOLP of the No Action Alternative.

As described in Section 3.7.3.2, *No Action Alternative*, these LOLP estimates rely on the assumption that 4,246 MW of coal generating capacity would continue to serve regional loads over the period of analysis. In future scenarios with limited to no coal capacity, the LOLP under MO4 would increase by 28 percentage points (from 27 percent to 55 percent) (limited coal) and 18 percentage points (from 63 percent to 81 percent) (no coal), compared to the No Action Alternative. Under the no-coal scenario, the difference in LOLP for MO4 versus the No Action Alternative would be smaller than under the base analysis with more coal generation. The No Action Alternative without coal generation would require about 28,000 MW of zero-carbon resource additions for generation year-round to restore the LOLP to 6.6 percent. Based on current technology, the majority of that would be solar, which would be more effective in the summer than in the winter. Because MO4 would have the largest LOLP in the summer, the added solar to reach the No Action alternative level would help reduce the LOLP issues from MO4.

**POTENTIAL REPLACEMENT RESOURCES AND ASSOCIATED COSTS**

To maintain power system reliability in the Northwest, additional generation resources would be needed. However, construction of new resources (e.g., gas, solar, wind, or pumped storage) and new transmission can easily take a decade to implement for planning, permitting, land acquisition, and physical construction. Setting aside the timing of construction, under the least-cost replacement generation portfolio, returning LOLP to the No Action Alternative level would require about 3,240 MW of single-cycle natural gas turbines. This portfolio would cost $156 million annually (2019 dollars), including annualized capital costs, fixed operations and maintenance, and insurance. The transmission analysis assumed these would be located in northeastern Oregon and southeastern Washington, which would optimize accessibility to an existing gas pipeline and transmission capacity. This does not include the annual cost of fuel to generate power, nor variable operation and maintenance costs. During critical water conditions, fuel plus variable costs would cost roughly $86 million annually (2019 dollars).

Under the zero-carbon resource portfolio, about 5,000 MW of solar power located across central Oregon, southern Idaho, and southeastern Washington, with 600 MW of demand response would reduce LOLP to the No Action Alternative level. The transmission analysis assumed solar would be located in central Oregon based on proposed projects in the interconnection queue but then also included adjacent areas with similar high solar output because such a large amount of solar generation would be needed. These solar power resources would require roughly 30,000 acres of land or roughly 47 square miles. Such a large buildout of solar capacity would likely result in additional but currently unknown impacts to natural and cultural resources, which may include vegetation, wildlife habitat, archaeological resources, and traditional cultural properties. The zero-carbon portfolio would cost $547 million/year for the solar power and $20 million[81]/year for the demand response (2019 dollars).

In future scenarios with limited coal generation capacity and assuming no new gas plants are built, restoring LOLP to 6.6 percent would require no incremental zero-carbon resources beyond what Bonneville (or the region) would already be procuring under MO4 in the base case. That is, if Bonneville (or the region) acquired 5,600 MW of zero-carbon resources to return MO4 to a No Action Alternative LOLP of 6.6 percent and either the limited coal capacity or the no coal capacity scenario occurred, the region would not need to acquire any more resources than it would have otherwise acquired under the No Action Alternative as a result of the additional coal retirements. Table 3-181 summarizes these values.

The analysis also does not include the additional amount of generation balancing reserves needed to integrate new renewable resources under a zero-carbon replacement resource portfolio. Generation balancing reserves allow grid operators to increase or decrease generation in response to changes in load and generation. In this analysis, the generation balancing reserves needed for the No Action Alternative are included in all modeling. However, additional reserves needed under a zero-carbon replacement resource portfolio have not been included and would increase the cost of the alternative. Currently, generation balancing reserves are generally supplied through the flexibility of hydropower or gas-fired generators in the region. With further technological advances, other options may be available in the future. MO4 substantially reduces the flexibility of the hydropower system to supply these generation balancing reserves.

[81] Demand Response costs in zero-carbon scenarios; $20 million for Bonneville finances, and $30 million for region finances)

**Table 3-181. Coal Capacity Assumptions, Zero-Carbon Replacement Resources under Multiple Objective 4 Relative to the No Action Alternative**

| | Base Case Coal Capacity Assumption in EIS (4,246 MW) | | | More Limited Coal Capacity (1,741 MW) | | | No Coal Capacity (0 MW) | | |
|---|---|---|---|---|---|---|---|---|---|
| **Alternative** | **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 |

Notes: The replacement resources for the No Action Alternative include demand-response, wind, and solar. The incremental resource builds under the more 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 scenarios.

**BONNEVILLE'S FISH AND WILDLIFE PROGRAM AND LOWER SNAKE RIVER COMPENSATION PLAN COSTS**

The Base Case analysis in the summary rate table for MO4 includes an estimate of $281 million in annual costs (adjusted to 2019 dollars) for the Bonneville Fish and Wildlife Program, which is consistent with the No Action Alternative. As previously discussed, Bonneville Fish and Wildlife Program funding decisions are not being made through the CRSO EIS process. However, Bonneville Fish and Wildlife Program costs are included in the EIS to inform a transparent cost analysis for each MO, as discussed in Section 3.19. Future budget adjustments would be made in consultation with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements. In the case of MO4, Bonneville included a range of potential Fish and Wildlife Program costs to acknowledge the possibility that MO4 could provide biological benefits to fish and wildlife and that this could, in turn, reduce the need for some offsite mitigation funded by the Bonneville Fish and Wildlife Program. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its Fish and Wildlife program and also acknowledges the uncertainty around both the magnitude of biological benefits and the potential impacts on funding, including the timing of funding decisions. For this reason, potential adjustments to the Bonneville Fish and Wildlife Program, which are estimated to range up to $105 million, are analyzed as part of the Rate Sensitivity analysis.

Under MO4, Bonneville would continue funding the operations and maintenance of the LSRCP, estimated at $34 million annually (adjusted to 2019 dollars), which is also included in the summary rate table and consistent with the No Action Alternative.

**EFFECTS ON TRANSMISSION FLOWS, CONGESTION, AND THE NEED FOR INFRASTRUCTURE**

**Bonneville Interconnections**

The developers of individual generation resources would have to construct certain transmission facilities (e.g., lines and equipment) to interconnect the resource to the transmission system. Those facilities would result in additional costs, which would vary depending on the location of the resource with respect to the transmission network, size of the individual project, and other factors.

Bonneville, for its part of the resource interconnection, would also have to construct additional transmission facilities at the point of interconnection in order to interconnect the new resource to the transmission system. The Bonneville portion of the interconnection would require equipment such as bulk transformers, circuit breakers, and other substation equipment, which may require the expansion of multiple existing substations. The addition of transmission substation infrastructure to accommodate interconnections can take several years to plan, permit, and construct, especially at those substations requiring expansion beyond the current footprint.

Based on the assumptions described above, Bonneville identified approximately $220 million in direct costs on the transmission network (which customers would fund, and Bonneville would repay in transmission credits) necessary to accommodate the interconnection for the least-cost portfolio under MO4. Bonneville identified $360 million in direct costs on the transmission network necessary to accommodate the interconnection for the zero-carbon portfolio under MO4. This would result in an annualized cost of $12 million to $19 million. The costs identified here include land and substation equipment in multiple locations near the replacement resources.

**Bonneville Transmission System Reliability and Operations**

Assuming that replacement resources were online by the time the changes in hydropower generation were implemented under MO4, no additional transmission reinforcements were identified beyond that in Bonneville's regular system assessments. Due to expected increases in loads in the Tri-Cities load service area, Bonneville's regular system assessments have identified several reliability projects, which are anticipated to occur within and beyond the 10-year planning horizon.

Because MO4 provides for reduced generation capability, there would also be a reduction in the number of online generating units at the CRS projects of the lower Snake and lower Columbia Rivers, particularly throughout the summer at the lower Columbia CRS projects. With a reduced number of operating units and uncertainty about the characteristics of replacement resources, there may be a reduced capability to provide voltage support and dynamic stability in response to significant disturbances throughout the Western Interconnection. This could result in reduced operating limits to avoid equipment damage and potential uncontrolled loss of load. However, the assumed operating limits were not changed because there is not enough certainty about the possible replacement resources to have confidence that changing the assumptions would increase the accuracy of the studies.

Operating at lower operating limits could result in increased congestion and result in redispatch of resources throughout the Western Interconnection to meet the required load demands at that time beyond that reported below under the Regional Transmission System Congestion Effects subsection. The effect on operating limits would vary based on the capability of resources online at the time and the location of those resources.

Limitations around voltage and dynamic response would be aggravated under scenarios with reduced coal generation, as coal generation plants provide similar support to the system as hydropower generators. Currently, renewable resources do not currently have the technology to provide comparable dynamic and frequency support. Depending on technological development, additional transmission system requirements may be needed under a zero-carbon resource portfolio as more solar generation is brought online to replace hydropower generation. Technology under development and implementation of additional requirements may be needed under a zero-carbon resource portfolio in order to have certainty that replacement solar resources will be able to provide adequate reactive and dynamic support to respond to larger transmission disturbances. Again, these transmission reinforcements can take several years to design, permit, and construct should they be needed.

**Regional Transmission System Congestion Effects**

The fluctuation in the number of congestion hours under MO4 relative to the No Action Alternative would be small in comparison to the fluctuations already caused by variations between runoff conditions (i.e., differences between high, median, and low run-off conditions). For most transmission paths under MO4, congested hours would not be a substantial issue in low runoff conditions regardless of replacement resource portfolio. In median and high runoff conditions, the west-to-east paths, particularly the Hemingway to Summer Lake transmission path, would experience a reduction in congestion relative to the No Action Alternative due to decreased hydropower generation available to be sent east.

Most north-to-south paths would remain relatively similar to the No Action Alternative with the exception of the Pacific DC Intertie. That path would have a larger increase in congestion as electricity is exported from the region to the south.

Overall, changes in the patterns of congestion under MO4 would have a relatively small or minor impact on congestion for most Pacific Northwest transmission paths and a minor to moderate increase in congestion hours for some north-to-south paths, particularly the Pacific DC Intertie during median and high runoff conditions. There would be a minor to moderate improvement in congestion hours on some west-to-east lines, particularly the Hemingway to Summer Lake transmission path.

If the assumed replacement resources are not in place when changes in hydropower generation are implemented under this alternative, the number of hours and location of congestion would change depending on which replacement resources are online at the time.

Under a limited to no-coal future, if a net reduction in resource availability also were to occur in the Pacific Northwest or other regions or both due to additional coal retirements, then the effects of CRS hydropower reductions, with or without replacement resources shift from what is reported above.

Detailed graphs depicting the number of hours of congestion along the individual paths under different water years appear in Appendix H.

**ELECTRICITY RATE PRESSURE**

**Bonneville Wholesale Power Rates**

Under MO4, there would be upward Bonneville wholesale power rate pressure for all portfolios. The highest upward pressures are related to the zero-carbon portfolio, which would result in the highest average wholesale rates associated with the Bonneville contracts. Table 3-182 presents the estimated wholesale power rate under MO4 based on changes in the amount of hydropower generated and the secondary (market) sales. Should the upward rate pressure lead to rate increases (i.e., assuming Bonneville or other entities were unable to balance the additional costs), Bonneville wholesale power rates could increase by $5.31 to $8.76 per MWh, depending on the replacement portfolio and whether Bonneville or the region replaced the lost generation. This represents an upward rate pressure between 15.3 to 25.3 percent in the average Bonneville wholesale power rate compared to No Action Alternative. Structural measure costs under MO4 would total $46 million. Appendix H, *Power and Transmission*, presents detailed information on structural measure costs and the effects on wholesale power rates.

Unlike MO3, cost additions for storage (batteries) were not added in MO4. Generation in the winter, in MO4, has nearly the same amount of average energy and LOLP per month as the No Action Alternative. The months when MO4 has significantly less energy and particularly less capacity for which battery storage would be useful are in the summer. But unlike MO3 where the generators at the lower Snake River projects are not available, in MO4 the possibility would exist to use the generators in a power emergency by temporarily diverting more water through the turbines instead of the spillway, if allowed.

Summary results for Bonneville's wholesale power rate pressure analysis in the Bonneville Finances scenario are presented in the first section of Table 3-181. As discussed in Section 3.7.3.1, the second section of Table 3-166 provides the cost pressure to the region of MO4 in light of potential carbon compliance and accelerated coal retirements.

Results for the Region Finances scenario are presented in Table 3-183. It is important to note that the rate pressure presented in this table is from the perspective of Bonneville's power rate. As such, in the Region Finances scenario, replacement resource costs are assumed to be recovered by regional utilities (not Bonneville), and therefore, are excluded from Bonneville's wholesale power rates. The Socioeconomic section shows the geographic distribution of rate impacts down to retail rates in both scenarios. As such, the costs which are missing from Bonneville rates in the Region Finances scenario are included in retail rate impacts of the consortium of public customers assumed to finance the resource replacement. The summary analysis focuses on the Bonneville Finances scenario, because this includes most of the relevant costs affecting its customer base, while the Region Finances scenario excludes real costs affecting regional rates which are not explicitly included in Bonneville's wholesale power rate.

***Bonneville Finances***

**Table 3-182. Average Bonneville Wholesale Power Rate ($/MWh) Under Multiple Objective 4, for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures 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 | |

Notes: Base Rate includes the Colville settlement payment, which has a 5 to 9 percent increase from the No Action Alternative.

<u>Base Case Analysis</u>

Base rate pressures range from 23.5 percent to 25.3 percent depending on the resource portfolio, with slightly higher rate pressure associated with the zero-carbon resource replacement. In the zero-carbon scenario, annual average cost pressure is $568 million per year (2019 dollars) which equate to upward pressure of 27 percent, and a small increase in preference customer loads leading to a 1.7 percent downward pressure on power rates, resulting in a 25.3 percent upward pressure on base rates. Rate pressure includes an increase in net secondary sales revenues associated with the large solar build, that is more than offset by large capital costs to finance and maintain the solar resource replacement, structural measure debt financing, and higher energy efficiency expenses associated with the demand response program. In the least-cost scenario, the $347 million per year in upward rate pressure is associated with lower net secondary revenues, and capital, fuel and O&M costs associated with the gas turbine resource replacement, as well as structural measure debt financing (2019 dollars), resulting in a 17.8 percent upward pressure on rates. In addition to these cost pressures, preference loads in the least-cost scenario are lower, contributing to a 5.8 percent upward pressure on power rates alone. Overall this results in a 23.5 percent upward pressure on base rates.

Rate Sensitivity Analysis

Rate sensitivities are presented in Table 3-182, lines 5 through 11 to provide quantitative estimates relative to the additional sensitivity analyses described in Section 3.7.3.1.

Line 5 of the cost analysis shows that Bonneville's fish and wildlife expenses could be as much as $105 million per year lower in MO4 than in the No Action Alternative and included in base rates, owing to higher spill and lower generation and the reduced need for mitigation efforts.

For line 6, Integration Services, other than energy shaping effects between HLH and LLH periods, changes in the value of lost flexibility due to increased spill and other constraints on the FCRPS under MO4 are not explicitly included in base rates. Generation inputs revenues for contingency reserves and balancing services are assumed to be the same as the NAA. However, the ability of the FCRPS to carry generation balancing reserves is reduced under MO4. To monetize the value of changes in contingency and generation balancing reserve carrying capability, the sensitivity analysis incorporates integration costs associated with contingency and balancing needs of replacement resources.[82]

Annual resource integration costs associated with replacement resources under MO1 were calculated using BP-20 operating and generation balancing reserve rates. Estimated annual integration costs for the 5000 MW solar resource replacement under MO4 for the zero carbon portfolio ranged from $121 million to $142 million.

Resource financing assumptions (line 7), which addresses alternative amortization periods to the 30 years assumed in base rates, shows upward cost pressure of $125 million per year in the zero-carbon portfolio and $33 million per year in the least-cost scenario.

Resource cost uncertainties (line 8) range from  upward cost pressure of $16 to$24 million from the base rates, depending on whether the zero-carbon or least-cost portfolio.

Demand response costs (line 9) could be lower than assumed in the $20 million/year[83] in base rates; a potential cost savings of $12 million per year is shown on the low end for this sensitivity. However, to account for the challenges to scaling up demand response programs in 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).

year higher than assumed in base rates if up to 50 percent of the program needed to be replaced with a 300 MW solar resource with battery technology instead

OMP costs associated with oversupply events (line 10) could be $2-4 million per year higher in the zero-carbon portfolio and a cost savings of $3 million to $4 million in the least-cost portfolio.

<u>Other Regional Cost Pressure</u>

Cost pressures to regional utilities, which do not necessarily impact Bonneville's power rates but could in the future, are presented in lines 13 and 14. Effects associated with regional carbon compliance laws are unknown, pending current legislation in Oregon and Washington as discussed in Section 3.7.3.1. If binding estimates effective in the future are enforced to the resource portfolio in MO4 alternative, regional utilities could face cost pressure relative to the No Action Alternative of $10-37 million per year. In the conventional least-cost scenario, carbon enforcement costs could range between $104 and $561 million per year.

As described in Sections 3.7.3.1, Availability of Coal Resources subsection, and 3.7.3.2, Effects on Power System Reliability subsection, regional utilities would need to add 8,800 MW of additional zero-carbon resources in the limited coal capacity scenario and 28,000 MW of additional zero-carbon resources in the no coal scenario to maintain regional LOLP at the No Action Alternative levels (6.6 percent). Lines 14 and 15 estimate the incremental zero-carbon resources costs needed by the region to maintain the No Action Alternative LOLP of at least 6.6 percent under MO4 in light of a limited or no coal assumption. An "incremental zero-carbon resource cost" occurs if the combination of (1) the resources Bonneville or the region is expected to acquire under the MO, plus (2) 8,800 MW (under the limited coal scenario) or 28,000 MW (under the no coal scenario), is less than the total amount of zero-carbon resources needed to return the region to the No Action Alternative LOLP of 6.6 percent.

For the limited coal capacity scenario under MO4, a minimum of 12,000 MW of zero-carbon resources would need to be added to maintain regional LOLP at the No Action Alternative level of 6.6 percent. Bonneville or the region is expected to acquire 5,600 MW of zero-carbon resources under MO4 in the base case. Adding 5,600 MW to 8,800 MW exceeds the minimum 12,000 MW, so this MO has no incremental cost impact on the region if a limited coal scenario is assumed. See Table 3-181.

For the no coal capacity scenario under MO4, a minimum of 30,000 MW of zero-carbon resources would be needed to maintain regional LOLP at the No Action Alternative level of 6.6 percent. Bonneville or the region is expected to acquire 5,600 MW of zero-carbon resources under MO4 in the base case. Adding 5,600 MW to 28,000 MW exceeds the minimum 30,000 MW, so this MO has no incremental cost impact on the region if a no coal scenario is assumed. See Table 3-183.

### *Region Finances*

Results for the Region Finances scenario are presented in Table 3-183. It is important to note the rate pressures in this table are from the perspective of Bonneville's wholesale power rates. In the Region Finances scenario, replacement resource costs are excluded from Bonneville's wholesale rate, with those costs collected from rates charged by other entities in the region, ultimately paid by the customers of utilities that would be receiving less power from Bonneville. The *Socioeconomic* section below shows the geographic distribution of rate impacts down to retail rates in both scenarios, so that these costs which are not in Bonneville rates in the Region Finances scenario are included in retail rate impacts of the consortium of public customers assumed to finance the resource replacement.

**Table 3-183. Average Bonneville Wholesale Power Rate ($/MWh) Under Multiple Objective 4, for the Base Case without Additional Coal Plant Retirements as well as the Rate Pressures 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%** |

### Market Prices

The secondary market sales under MO4 would vary depending on the replacement resource. Under MO4, the average market price would increase from $19.42 under the No Action Alternative to $20.82 per MWh under the conventional least-cost portfolio and decrease to $19.32 per MWh under the zero-carbon portfolio. The price under MO4 would fluctuate more over the course of the year relative to the No Action Alternative due to changes in hydropower generation and perhaps the solar generation profile across the seasons as can be seen in Figure 3-188, which is under the least-cost portfolio.

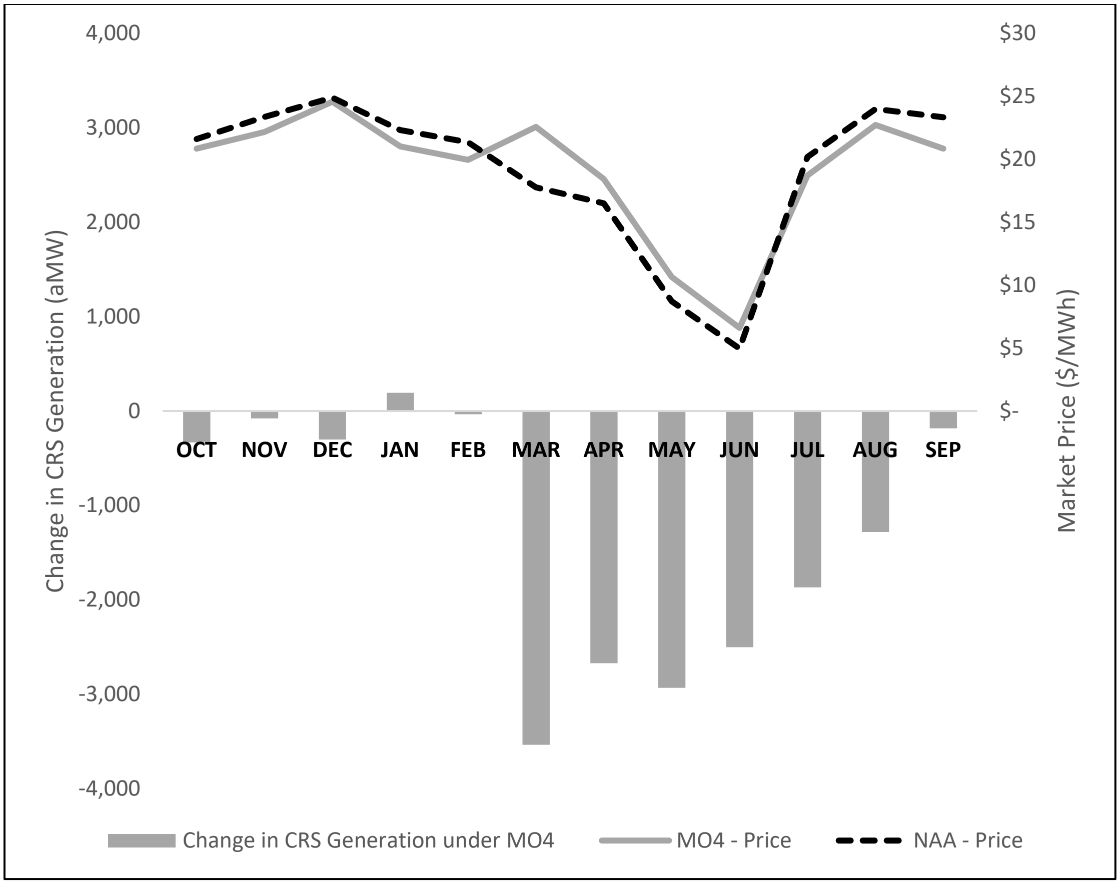


**Figure 3-188. Monthly CRS Generation (aMW) and Market Price ($/MWh) under Multiple Objective 4**

Note: The right axis is the market price ($/MWh). The left axis is generation from the CRS projects by month (aMW).

Source: Power Analysis

**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.

**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 rate pressure lead to increases in rates, the average retail rates under MO4 would range from 10.48 cents per kWh to 10.52 cents per kWh for residential end users, depending on the replacement portfolio with generally lower rates for customers whose utilities do not receive power from Bonneville and higher rates for customers of utilities receiving power from Bonneville. On average, counties would experience a 2.8 to 3.2 percent upward rate pressure effect on their residential retail rate, depending on the replacement portfolio, relative to the No Action Alternative. The largest effect for all end-user groups under MO4 is a 36 percent upward rate pressure in the industrial retail rate.

**BONNEVILLE FINANCIAL ANALYSIS**

As previously described, the Bonneville financial analysis considers the effects of the MOs on future cash flows over a 30-year financing period for potential replacement resources. For MO4, the discounted NPV of the cash flow effects under each resource replacement portfolio are described in Table 3-184 below. This NPV analysis is Bonneville specific and does not capture wider societal impacts. This NPV analysis uses a risk adjusted discount rate of 7.9 percent and a 30-year timeframe.

The sensitivities in this analysis are described in the Power Rates section, above.

**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** |

**SOCIAL AND ECONOMIC EFFECTS OF CHANGES IN POWER AND TRANSMISSION**

Except where noted, this section describes the base analysis for MO4 without considering the range of additional costs shown in Table 3-185 and without the retirement of additional coal-plants.

**Social Welfare Effects**

This social welfare analysis employs both the market price and production cost methods based on the base case for this analysis, assuming no additional coal plant retirements. Section 3.7.3.1, *Base Case Methodology and Cost Sensitivities Analysis*, describes the differences between these two methods. Table 3-185 presents the market value of the reduction in Pacific Northwest hydropower generation under MO4 as compared with the No Action Alternative. Based on the market price method, the average annual economic effect of MO4 is a $180 million cost. If these social welfare effects persist over a 50-year timeframe, the present value costs would be $4.8 billion.

**Table 3-185. Average Annual Social Welfare Effect of Multiple Objective 4 Based on the 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** |

Table 3-186 evaluates the social welfare effects of MO4 based on the additional costs of adding enough capacity to the system to meet power demand given the reduction in hydropower generation described in Table 3-180. Based on this approach, the social welfare effects of MO4 range from an average annual cost of $380 million (assuming a least-cost replacement resource portfolio) to $650 million (assuming a zero-carbon replacement resource portfolio). If these social welfare effects persist over a 50-year timeframe, the present value costs would be $10 billion to $18 billion.

**Table 3-186. Average Annual Social Welfare Effect of MO4 Based on the Increased Cost of Producing Power to Meet Demand (2019 U.S. Dollars)**

| | Replacement Resource Portfolio | |
|---|---|---|
| **Production Cost Factor[1/]** | **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 |

Note: Estimates are rounded to two significant digits and may not sum to the totals reported due to rounding.
1/ Negative values in the table represent an increase (net cost) in the cost of producing power.

### Regional Economic Effects

Estimated average retail electricity rates would experience upward rate pressure under MO4 with increases up to over 1 cent per kilowatt-hour in certain counties. These upward retail rate pressures may negatively affect residential, commercial, and industrial end users due to the increase in spending on electricity relative to the No Action Alternative.

### Residential Effects

Examining potential residential retail rate increases on a geographic basis, the effects of MO4 would negatively affect residential end users across the Pacific Northwest. Many residential end users would experience average upward rate pressure greater than 5 percent relative to the No Action Alternative—many would experience upward pressure much higher than historical year-to-year rate changes. The upward residential rate pressure under MO4 would range as high as 18 percent for certain counties while some utilities that would not purchase Bonneville power could be largely isolated from the higher rate effects with some experiencing increases in rate pressure as low as 0.04 percent due to beneficial market effects. However, MO4 also could result in higher regional total production costs generating adverse rate effects on utilities that do not purchase power from Bonneville.

Under MO4, the largest residential rate pressure effects would occur in small non-metropolitan urban areas, where, under the zero-carbon portfolio, average upward rate pressure effects of 3.4 percent and 4.6 percent would occur in the region-financed or Bonneville-financed portfolios, respectively. Rural areas under MO4 would experience smaller rate pressure increases relative to No Action, ranging from 1.1 to 2.4 percent. By CRSO region, the effects would be concentrated in Regions A and D. Table 3-187 presents the average rate pressure increase by CRSO region. Under a zero-carbon Bonneville-financed portfolio, Region A and D would experience average increases of 3.8 percent and 5.0 percent, respectively.

**Table 3-187. Average Residential Retail Rate Pressure Effect by Columbia River System 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% |

Figure 3-189 shows the potential residential rate pressure effects under MO4 relative to the No Action Alternative. Upward rate pressure effects would occur across the entire region with higher increases occurring under the zero-carbon portfolio due to the high replacement portfolio costs.

Over time, the difference in retail rate pressure between MO4 and No Action would increase due to wholesale rate pressures. Table 3-188 presents the change in 2022 and 2041 for all end-user groups. Considerable uncertainty surrounds load and rate pressures over time, but these changes under MO4 would likely have negative effects over the long term for end user retail rates.

To the extent that the upward rate pressure leads to changes in rates, end users would increase spending on electricity. Examining average expenditures, under MO4, the average residential end user would spend between $28 and $32 more per year on electricity. The highest effects across the Pacific Northwest would result in up to $160 more spent per year on electricity compared to the No Action Alternative.

Categorizing the number of households by expenditure effect, roughly a quarter of all households would experience increases above 5 percent in their spending under the zero-carbon Bonneville-financed portfolio MO4 relative to the No Action Alternative (Table 3-189). Under the zero-carbon Bonneville-financed portfolio, less than 1 percent of all households would experience increases above 10 percent. Under the zero-carbon portfolios, approximately a third of all households would experience a minimal change between 0 and 1 while only 12 percent would experience that range under the least-cost portfolios.

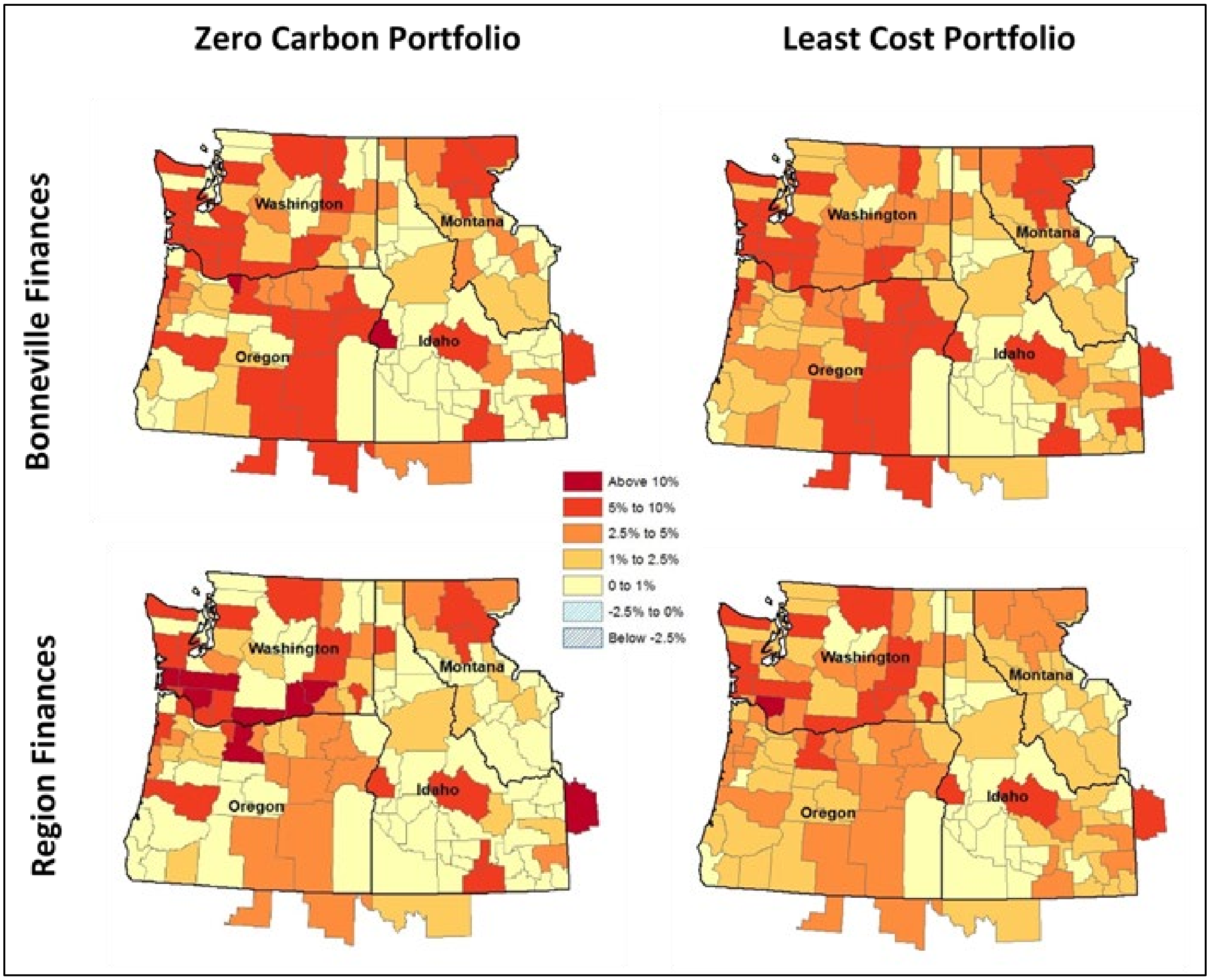


**Figure 3-189. Residential Electricity Rate Pressure Effects by Portfolio for Multiple Objective 4 for the Base Case Without Additional Coal Plant Retirements**

**Table 3-188. Average Upward Retail Rate Pressure Effect in 2022 and 2041 under Multiple Objective 4 Relative to the No Action Alternative**

| | | Residential | | Commercial | | Industrial | |
|---|---|---|---|---|---|---|---|
| **Financing** | **Portfolio** | **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% |

These expenditures under MO4 would, on average, account for 1.737 to 1.742 percent of household income. This represents a 0.18 to 0.31 increase in percent of income spent on electricity relative to the No Action Alternative. The portion of income spent on electricity for some residential end users would increase by up to 10 percent, though these effects would occur in some counties with higher-than-average household incomes to begin with (e.g., an increase from 1.3 percent of income to 1.6 percent, which is already below the regional average) (Census 2016). The total increase in household spending on electricity across all Pacific Northwest households would be between $160 million and $180 million per year.

**Table 3-189. Percentage of Residential End Users who Experience Changes in Electricity Expenditures by Size of Expenditure Change in each Portfolio under Multiple Objective 4**

| Sector | Expenditure Change | Bonneville Finances: Zero Carbon | Bonneville Finances: Conventional Least Cost | Region Finances: Zero Carbon | Region Finances: 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% |

Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

Under MO4, expenditures and rates would increase, which would likely result in end users reducing their consumption based on the elasticity of demand. If consumption were reduced, the average household could reduce consumption and save between $28 and $32 per year from conservation under MO4 depending on the portfolio, partially offsetting the increase in residential rates; however, if consumption remained constant, then there would be no reduced costs (Census 2016). In counties where the increase in rates would be highest, households that decreased consumption most could reduce the cost increase by as much as $160 per year in the highest rate increase portfolio (Bonneville-financed zero-carbon).

This analysis considers how the region-wide changes in household spending on electricity would affect demand for other goods and services across the region. That is, the increased spending on electricity may reduce spending on other items, affecting regional economic productivity. This analysis applies IMPLAN to model the increased spending on electricity as a reduction in household income (direct effect), and quantifies the multiplier effects on interrelated economic sectors (indirect and induced effects). This analysis finds that the potential increased cost of household electricity could result in the loss of between $170 million and $190 million in regional output (sales) and between 1,100 and 1,200 jobs (Table 3-190). The majority of regional economic effects would occur Washington and Oregon.

**Table 3-190. Regional Economic Effects from Changes in Household Spending on Electricity**

| Effect | Bonneville Finances: Zero Carbon | Bonneville Finances: Conventional Least Cost | Region Finances: Zero Carbon | Region Finances: 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 |

Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy

**Commercial and Industrial Effects**

Commercial and industrial retail rates would also experience upward rate pressure under MO4 with average upward rate pressure between 3.0 and 3.4 percent for commercial end users and between 4.0 and 4.5 percent for industrial end users relative to the No Action Alternative across the region. Areas with large numbers of commercial entities (King, Pierce, Snohomish, and Multnomah Counties) would continue to have relatively low rates and would experience a range of changes (5.8 percent in Pierce County, 0.93 percent in Multnomah County, and 2.4 percent in King County)). The exception under MO4 is Snohomish County, where upward rate pressure would range up to range up to 9.4 under the zero-carbon Bonneville-financed portfolio because the retail utility serving that county is a Bonneville customer with limited generating resources of its own. Industrial effects follow similar patterns as commercial effects; however, the upward rate pressure effects are larger in areas with industrial entities. Pierce County would experience rate increases up to 7.1 percent and Snohomish County would experience rate pressure increases up to 12 percent under the zero-carbon Bonneville-financed portfolio. Over time, these retail rate differences would increase due to wholesale rate pressure.

These upward rate pressures under MO4 could lead to increasing expenditures on electricity for commercial and industrial entities. For commercial end users, the upward rate pressure would be as high as an average of $1,200 per year in certain counties. Given the large amount of electricity industrial end users tend to require, the total amount of electricity expenditures could increase by as much as $25,000 per year. The highest percentage increase and dollar increase would not occur in the same county, as the largest percentage change would occur in a county with a lower base rate. The highest percentage increase would be a 34 percent increase in electricity expenditures for the highest impacted industrial end users, which could cause these end users' demand to fall between 4.1 and 34 percent, depending on the responsiveness (i.e., elasticity) of the industrial end users to changes in electricity price (EIA 2018). In addition to falling electricity use among individual businesses, large rate increases could cause industry to leave the region. Historically, the region had a large aluminum industry, but past increases in electricity prices contributed to those industries shutting down operations in the region, largely in favor of production in other countries (NW Council 2018). Additional large price increases associated with MO4 could similarly cause electricity-heavy industries to shift production out of the region.

Table 3-191 presents the percentage of commercial and industrial entities that would experience a specific range of expenditure effects relative to the No Action Alternative.

**Table 3-191. Percentage of Commercial and Industrial End Users Who Experience Changes in Electricity Expenditures by Size of Expenditure Change under Multiple Objective 4**

| Sector | Expenditure Change | Bonneville Finances: Zero Carbon | Bonneville Finances: Conventional Least Cost | Region Finances: Zero Carbon | Region Finances: 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% |

Note: Estimates are rounded to two significant digits and may not sum to 100 percent due to rounding.

Under MO4, the total upward rate pressure across commercial businesses in the Pacific Northwest would be between $51 million and $58 million per year. This analysis uses the IMPLAN model to quantify the multiplier effects of the change in commercial sector productivity (Table 3-192). The multiplier effects reflect how the increased costs of doing business may affect demand for inputs to production across commercial businesses. This analysis finds that the increased cost of electricity to regional commercial businesses would result in the loss of between $84 million and $96 million in regional output (sales) per year and between 580 and 650 jobs. The majority of regional economic effects would occur Washington and Oregon.

**Table 3-192. Regional Economic Effects from Changes in Commercial Business Spending on Electricity**

| Effect | Bonneville Finances: Zero Carbon | Bonneville Finances: Conventional Least Cost | Region Finances: Zero Carbon | Region Finances: 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 |

Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy

Under MO4, the total increase in spending on electricity across industrial businesses in the Pacific Northwest would be between $190 million and $210 million per year. Similar to the commercial spending analysis, the IMPLAN model is used to quantify the multiplier effects of the change in industrial sector productivity (Table 3-193). This analysis finds that the increased cost pressure of electricity to regional industrial businesses would result in the loss of between $300 million and $340 million in regional output (sales) and between 2,000 and 2,300 jobs. Again, the majority of regional economic effects would occur Washington and Oregon.

**Table 3-193. Regional Economic Effects from Changes in Industrial Business Spending on 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 |

Note:1/ Negative values in the table represent a decrease (net loss) in the output and employment of the regional economy

The effect on commercial and industrial businesses described above is predicated on the region acquiring replacement resources for the reduction in hydropower generation. If the replacement resources were not developed, there would be a large increase in risk to reliability. Power shortages might occur in about a third of the years, with some years experiencing more than one event. These power shortages (blackouts) would have substantial effects on businesses.

**Other Social Effects**

Under MO4, there would be large retail rate increases in multiple counties, as described above. These rate increases could lead certain end users to forego normal expenditures, even if slightly, given the increased energy burden from electricity costs. End users often forgo heating and cooling as well as food purchases due to energy bills (EIA 2015). MO4 would increase the likelihood of such occurrences relative to the No Action Alternative. These instances of foregoing purchases or inadequately heating or cooling a home could have negative health effects.

If replacement resources were built in the region, the LOLP would be reduced to the No Action Alternative level so there would not be additional safety concerns compared to the No Action Alternative. However, if the region (Bonneville or other regional entities) did not acquire additional resources, there would be a large increase in risk to reliability. Power shortages might occur in about a third of the years, with some years experiencing more than one event. These power shortages would lead to additional safety concerns, such as blackouts, particularly in the late summer. Safety concerns include heating and cooling, hospitals and other power-dependent medical support, lighting for safety, roads, and traffic lights. Because it can take many years to plan, site, permit, and construct new resources, the region might face this increased reliability risk after hydropower generation is reduced in MO4 until the new resources are available.

**SUMMARY OF EFFECTS**

Under MO4, hydropower generation would decrease by over 10 percent compared to the No Action Alternative. The FCRPS would lose over 12 percent of the firm power available for long-term, firm power sales to preference customers. The decrease in hydropower generation would increase the LOLP. If no new resources were built, the region would experience substantial power shortages in about one in every three years. To avoid the power shortages, large amounts of replacement power resources and would be necessary to bring LOLP to the No Action level. With the loss in hydropower generation and with replacement resources, upward wholesale power rate pressures would be 15 to 25 percent.

The reduction in hydropower generation across the Pacific Northwest (a reduction of 1,400 aMW including Federal and non-Federal projects) would result in an average annual economic cost of $189 million when valued at the market price for the foregone power generation. However, the estimated increase in the marginal cost of producing power to meet demand based on additional average annual fixed and variable costs is $380 million to $650 million. If these social welfare effect persist over a 50-year timeframe, the present value costs would be up to $18 billion. These values are estimates of the net economic effects from a national societal perspective.

Regional utilities that purchase most or all of their power from Bonneville would experience larger effects than IOUs or other public utilities that do not purchase Bonneville power directly. Consequently, residential and commercial end users would experience upward retail rate pressure effects of up to 11 and 13 percent, with over a quarter of businesses experiencing over a 5 percent upward rate pressure under the highest rate-effect portfolio. In the I scenarios with limited or no coal generation in the region, the upward rate pressure associated with MO4 would likely be substantially higher (Table 3-194).

The increased cost of electricity could increase the costs of living and doing business in the Pacific Northwest, resulting in regional economic impacts of $630 million in lost output (sales) and 4,000 jobs.

**Table 3-194. Summary of Effects Under Multiple Objective 4 without Additional Coal Plant 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 |

| 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 $19 million |
| Average Bonneville wholesale power rate pressure (base analysis)<br>Potential Range of Bonneville wholesale power rate ($/MWh)<br>Potential range of Bonneville wholesale power rate pressure including rate sensitivities | $34.56 | +15.3% to +25.3%<br>$38.87/MWh to $43.32/MWh<br>17.9% to 40.8% |
| Annualized transmission rate pressure relative to NAA (%) | ——[1/] | +1.6% to +1.9% |
| Average annual social welfare effects ($): 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%<br>(+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%<br>(+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%<br>(+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 |

Note: The estimated LOLP effect, and resulting social welfare and rate effects, rely on the best available information regarding planned coal plant retirements as of 2017 when the modeling efforts began for this analysis. Based on regional energy policy developments and expected coal-plant closures as of 2019, Section 3.7.3.1 discusses the sensitivity of the results of the analysis to these assumptions.

/1 The analysis of the No Action Alternative for these effect categories provides a baseline against which the MOs are compared. Thus, the No Action Alternative results presented in this table describe the baseline magnitude of power and transmission values (e.g., for LOLP and rates) and the MO4 results describe the change relative to No Action. A "——" indicates an effect category that is not relevant to the No Action Alternative because it only occurs as a result of implementing the MOs (e.g., the need for new generation and transmission infrastructure and associated costs).

/2 The production cost method for valuing social welfare effects of the MOs relies on information on the fixed and variable costs of replacement generation resources. These costs are not relevant to the No Action Alternative.

### 3.7.4 Tribal Interests

Many tribes in the study area receive electricity through Bonneville. Some have tribal utilities that get power directly from Bonneville and some are served by public utilities that get power from Bonneville. Therefore, any upward or downward movement in power rate pressure would directly affect tribes. Rate discussion is included above and also in more detail in Appendix J, *Hydropower*. MO4 would result in the greatest rate increases, followed by MO3.

The Confederated Tribes of the Colville Reservation (CTCR) and the Spokane Tribe of Indians (likely starting in 2021) receive annual payments from Bonneville as compensation for tribal lands inundated by Lake Roosevelt. The payment is based on annual average generation produced at Grand Coulee Dam as well as the power used to pump water to Banks Lake for irrigation. Appendix J provides a summary of the annual values for Grand Coulee generation for each of the MOs. Details of the monetary value are provided in Chapter 4 of Appendix H, *Power and Transmission*. All MOs produced less generation at Grand Coulee than the No Action Alternative, but they are relatively minor changes from the No Action Alternative averages (less than -2.5 percent change depending on the alternative). Another driver for the calculation of the payment is the price of power and revenue from power sales. Based on the combination of reduced generation at Grand Coulee and changes in market prices for power, the estimated payment would increase in MO1, MO3, and MO4, while MO2, would see a minor decrease in the calculated payment as shown below in Table 3-195.

**Table 3-195. Estimates of Percent Change in the Annual Payment to the CTCR and Spokane 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% |

# 3.8 AIR QUALITY AND GREENHOUSE GASES

## 3.8.1 Introduction

The following sections describe existing conditions pertinent to regional air quality and greenhouse gas (GHG) emissions in the Columbia River Basin region. While air pollutants and GHGs may be emitted from similar sources, such as fossil fuel combustion, they have distinct consequences to human and environmental health. Air pollutants affect ambient air quality relatively close to their sources where they may more directly affect human and ecological health. On the other hand, GHG emissions, regardless of where they are generated, combine in the Earth's atmosphere, ultimately affecting global climate systems. Air pollutants and GHG emissions are relevant to this EIS given the potential for the action alternatives to affect the following emissions sources:

- **Power generation:** Given variable emissions profiles of power-generating sources, changes in the fuel mix affect air pollutant and GHG emissions. For example, fossil fuel combustion generates air pollutant and GHG emissions whereas hydropower generation does not.
- **Navigation and transportation:** Modal changes, such as tradeoffs between barge and road or rail, may affect levels of air pollutant and GHG emissions given the relative efficiencies in transporting goods and the variable emissions profiles of these different modes of transport.
- **Construction activities:** Construction, demolition, and maintenance activities may release emissions or fugitive dust (or both) from construction vehicles and equipment use.
- **Other emission sources:** Operational changes at reservoirs may result in particulate matter (PM) emissions from exposed sediment, as well as changes to reservoir methane emissions.

### *3.8.1.1 Area of Analysis*

The area of analysis for air quality and GHG emissions reflects the area over which air pollutant and GHG emissions are generated from the above activities, as described in Section 3.7, *Power Generation and Transmission*, and Section 3.10, *Navigation and Transportation*. Construction activities and other emissions sources are focused at the CRS hydropower projects and reservoirs. Section 3.8.3 describes air quality and GHG emissions at the state level for Washington, Oregon, Idaho, and Montana. The extent to which air quality and GHG emissions are affected in each state varies by alternative and is evaluated in Section 3.8.3. Information on air quality and GHG emissions, as well as emissions reductions targets, is generally available and most relevant at state or county level. Thus, the affected environment discussion summarizes available information at state and county levels as opposed to by the four CRS regions. The environmental consequences analysis provides information at the CRS-region level, where feasible.

## 3.8.2 Affected Environment

This section separately describes the affected environment for air quality in the region (Section 3.8.2.1) and GHG emissions (Section 3.8.2.2).

### *3.8.2.1 Air Quality*

Air pollutants include criteria pollutants (regulated under the Clean Air Act [CAA]), hazardous air pollutants (HAPs), and volatile organic compounds (VOCs). In the Columbia River Basin, these air pollutants are emitted by stationary point sources (e.g., industrial plants) and mobile sources (e.g., vehicular travel). The emissions in turn affect ambient air quality to which people and ecological resources are exposed.

**AIR QUALITY REGULATIONS AND MANAGEMENT**

Air pollutants are regulated on national, state, and local levels to protect public health and the environment. The CAA is the Federal law that regulates air emissions in the United States. Under the CAA, the U.S. Environmental Protection Agency (EPA) establishes National Ambient Air Quality Standards (NAAQS) for common pollutants. The six CAA criteria pollutants are: carbon monoxide (CO), lead, ground-level ozone ($O_3$), nitrogen dioxide ($NO_2$), particulate matter ($PM_{2.5}$ and $PM_{10}$), and sulfur dioxide ($SO_2$) (EPA 2018a).

These pollutants affect human health and the environment in different ways. For example, depending on the level of exposure, carbon monoxide can cause hypoxia; lead generates neurotoxic effects in children; $NO_2$, ozone, PM, and $SO_2$ can lead to respiratory effects. These pollutants can also adversely affect soil, vegetation, water quality, fish, and wildlife. Appendix G, *Air Quality and Greenhouse Gas Emissions,* describes sources of emissions and potential adverse effects of exposure to these criteria pollutants. The EPA establishes two types of NAAQS: primary NAAQS protect human health, including the health of sensitive subpopulations; secondary NAAQS protect public welfare, which includes protection against damage to water, soil, and adverse effects on visibility. Appendix G identifies the current NAAQS by pollutant.

Individual states are responsible for developing state implementation plans (SIPs) that meet or exceed EPA NAAQS. SIPs must contain control measures for emissions that cross state lines (EPA 2013). All Pacific Northwest states have EPA-approved SIPs for meeting air quality standards.

Title V of the CAA requires operating permits for all major sources of pollutants as well as a 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).

requirements as part of the CAA New Source Review (NSR) Permitting program. For new major sources of pollutants or existing sources planning major modifications, there are two types of additional permits: Non-attainment NSR permits and Prevention of Significant Deterioration (PSD) permits. Non-attainment NSR permits apply to sources located in an area that is out of attainment with the NAAQS (i.e., “nonattainment areas”). These permits are specific to each nonattainment area and require the lowest achievable emission rate, offsetting emissions, and may specify additional requirements (EPA 2016b).

PSD permits apply to sources located in an area that is in attainment or unclassifiable within the NAAQS.[2] PSD permitting requires an air quality analysis to confirm that any new emissions will not cause or contribute to a violation of NAAQS or a PSD increment threshold, and installation of the best available control technology. In particular, PSD permits provide extra protection to Class I areas, which are defined as having special natural, scenic, recreational, or historic value in a national or regional context. Chapter G-4 of Appendix G describes EPA’s Regional Haze Rule and Class I areas in further detail, as well as providing a map of Class I areas in the Pacific Northwest. While NAAQS define a maximum allowable level of emissions, a PSD increment is the maximum increase permitted to occur relative to a baseline concentration for a given pollutant. “Significant deterioration” occurs when the amount of new criteria pollutant emissions exceeds the applicable PSD increment. Through the three permitting types, the NSR program ensures new or modified sources remain compliant with the aims of the CAA to protect air quality (EPA 2019c).

In addition, the General Conformity Rule, established under Section 176(c)(4) of the CAA, ensures that the actions taken by Federal agencies do not cause or contribute to violations of the NAAQS. The EPA defines “*de minimis*” levels of criteria air pollutant emissions as thresholds (e.g., tons per year) above which a conformity determination must be performed. A conformity determination requires evaluating plans and programs to ensure a project does not negatively impact a state’s air quality control strategy nor the requirements of the CAA (EPA 2014c).

Air quality in Oregon, Washington, Idaho, and Montana generally meets the NAAQS, with some exceptions for PM. Table 3-196 identifies the areas within the Columbia River Basin that do not currently meet particular NAAQS (i.e., “nonattainment areas”), as well as areas that previously did not meet standards but have since reached the standard (i.e., “maintenance areas”) (EPA 2013). Currently, the only nonattainment areas in the region are for $PM_{2.5}$ (in Oakridge County, Oregon; West Silver Valley, Idaho; and Libby, Montana), and $PM_{10}$ (in Lane County, Oregon; Fort 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).

**Table 3-196. Nonattainment and Maintenance Areas Within the Columbia River Basin by 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 |

Source: EPA (2018b)

Ambient air quality in the United States is often measured in terms of concentrations of various pollutants, with overall air quality reported as an index score called the Air Quality Index (AQI). The AQI is reported based on the threat to human health ranging from 0 to 500, where 301 to 500 is deemed hazardous and 100 generally aligns with the NAAQS (EPA 2014).

All Pacific Northwest states have high rates of good air quality days relative to the national average (EPA 2018c). In the Columbia River Basin, for the year 2016, the AQI did not reach hazardous levels at all (EPA 2018c). For 89 percent of reporting days in 2016, all counties in the region reported AQI scores of zero to 50, which indicates air pollutant concentrations are generally well within the ambient air quality standards (EPA 2018c).

In addition to the nonattainment and maintenance areas, the Columbia Gorge National Scenic Area is a protected natural scenic area that runs 83 miles along the Columbia River in southern Washington and northern Oregon. The National Scenic Area Act of 1986 requires the protection and improvement of resources of the Gorge. Regional haze is a key concern in this area as it creates visibility issues that affect its recreational and scenic value. Air quality studies of the Gorge Area identified on-road vehicles as a source of the regional haze (ODEQ 2011). Chapter

G-4 of Appendix G describes regional haze and relevant Class I areas in further detail, along with a map of Class I areas in the Pacific Northwest.

### AIR POLLUTANT EMISSIONS LEVELS AND SOURCES

The EPA publishes the National Emissions Inventory (NEI) every 3 years to catalog emissions by source, county, and pollutant. Emission levels of air pollutants from anthropogenic sources from all sectors across the Pacific Northwest have remained relatively stable since 2010. In addition to anthropogenic sources, some of the largest sources of emissions stem from natural occurrences. Wildfires, for example, are a major cause of regional air pollutants, contributing 38 percent of regional CO emissions and 45 percent of $PM_{2.5}$ (EPA 2018d). Regional (all of Idaho, Montana, Oregon, and Washington) air pollutant emissions by source are shown in Figure 3-190 for each criteria pollutant and VOCs.

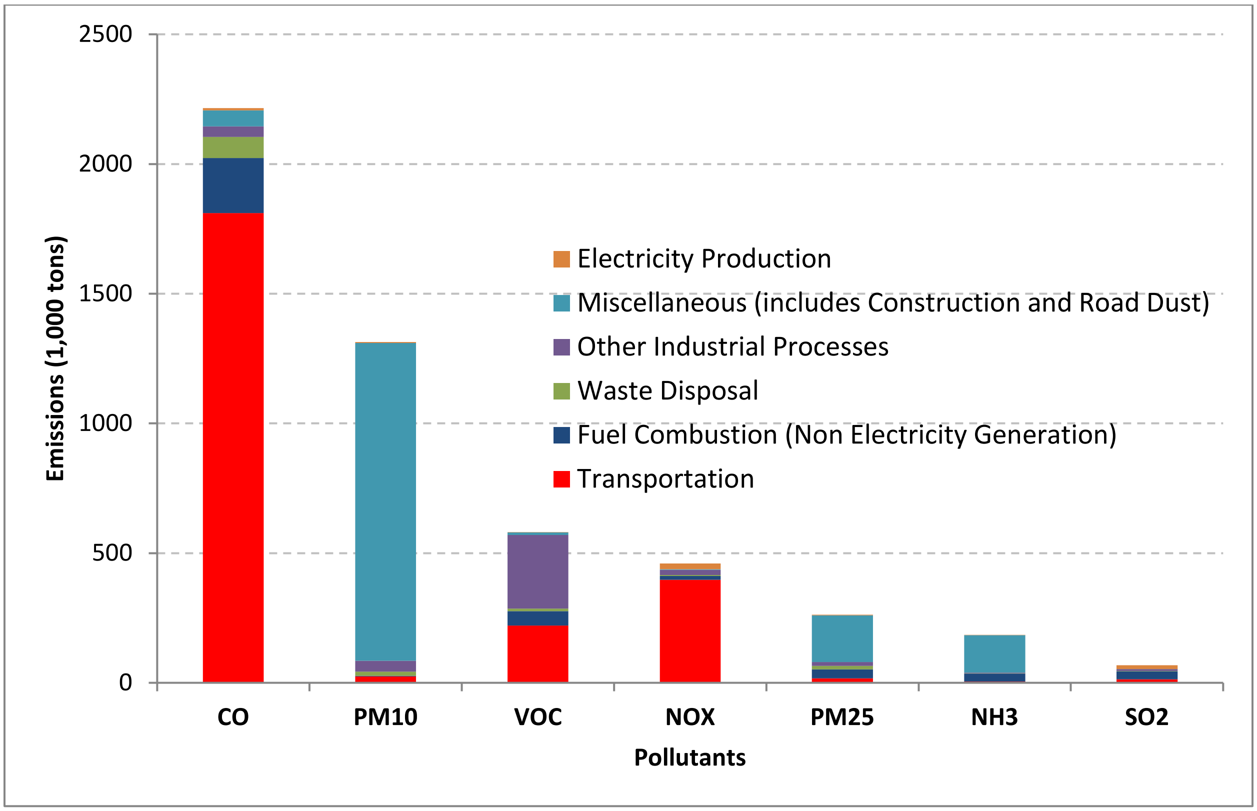


**Figure 3-190. Regional Air Pollutant Emissions in 2016**

Note: Does not include wildfires or prescribed fires.

Source: EPA (2018d)

#### Air Pollutant Emissions from Power Generation

As identified in Figure 3-190, electricity production in the Pacific Northwest contributes a minor level of air pollutant emissions relative to other sources. This is because the generation of electricity from hydropower resources does not result directly in air pollutant emissions, though construction and maintenance of these projects have the potential to generate emissions

(EPA 2018e; U.S. Energy Information Administration [EIA] 2018b). Similarly, power generation through other renewable sources, including solar and wind energy, does not contribute to air pollution. The relatively low level of criteria pollutant emissions that are associated with electricity production mainly result from fossil fuel combustion, including natural gas and coal power plants (EPA 2018f).

Air pollutant emissions from power generation in the Pacific Northwest make up a much smaller share of total regional emissions than at the national level. For example, nationally, emissions of $SO_2$ from electricity generation account for approximately 52 percent of total $SO_2$ emissions whereas $SO_2$ emission from electricity generation in the Pacific Northwest account for approximately 25 percent of all $SO_2$ emissions (EPA 2018d). Similarly, regional nitrogen oxides ($NO_x$) emissions from electricity generation account for 4 percent of total emissions, as compared with 10 percent nationally. These low levels are due to the relative prominence of hydropower-based electricity generation.

***Air Pollutant Emissions from Transportation***

Mobile vehicles are segmented in the EPA NEI into on-road vehicles, locomotives, marine vessels, aircraft and non-road equipment, or vehicles or equipment (discussed below in the construction section). Excluding natural sources and wildfires, transportation is the largest source of multiple air pollutants in the Pacific Northwest (EPA 2018d). On-road vehicles account for the majority of transportation pollutants; heavy- and light-duty vehicles account for 70 percent of transportation CO emissions, 66 percent of $NO_x$, and 60 percent of VOCs.

As compared with on-road vehicles, locomotives and marine vessels in the region contribute less to the total air pollutant emissions. This difference is due to fewer ship and train miles travelled compared to passenger car and cargo trucks, as well as a higher efficiency per distance traveled in transporting either cargo or passengers as compared with on-road motor vehicles. For freight cargo, trucks carried roughly 72 percent of all cargo tons in the Pacific Northwest (Bureau of Transportation Statistics 2018). Cargo trucks emit three times as much $NO_x$ per ton-mile[3] compared to railroad and four times as much per ton-mile as compared with inland barges (0.94 grams per ton-mile compared to 0.28 and 0.21, respectively) and create six times as much PM (0.06 g/ton-mile compared to 0.01 and 0.007) (Kruse, Warner, and Olson 2017). Thus, barge-based freight shipping is associated with the lowest air pollutant emissions profiles as compared with other modes of moving freight.

***Air Pollutants and Fugitive Dust from Construction or Other Operational Changes***

Construction activities such as bulldozing, hauling, and construction vehicle travel generate air pollutant emissions and fugitive dust. Fugitive dust emissions from construction activities represent roughly three percent of all $PM_{10}$ emissions in the region (EPA 2018d). The largest

[3] A ton-mile is a ton of cargo transported for a mile.

sources of PM emissions in the region are unpaved road dust (29 percent of PM emissions) and crops and livestock dust (24 percent) (EPA 2018d).

Exposed sediment and soils, for example due to changing reservoir levels, may also generate fugitive dust (Reclamation 2011; San Joaquin Valley Air Pollution Control District 2011). Dust from changing river or lake levels occurs when wind blows dry, exposed soils causing PM emissions (Western Regional Air Partnership 2006). The potential for dust emissions is determined by the amount of erodible soil, which can shift because of changes in hydroelectric project reservoirs exposing lake or riverbeds. Fugitive dust emissions are also dependent on the type of soil exposed, wind velocity, and temperature and precipitation (San Joaquin Valley Air Pollution Control District 2011). Dust emissions typically have localized short-term air quality effects; however, extreme events have occurred including one in Oregon in 2015, which resulted in a meteorological event 480 miles away from the lakebed source of the dust (Washington State University 2015).

High-wind dust events, as defined by recent EPA Exceptional Events guidance, involve sustained wind speeds of 25 miles per hour (mph). Average wind speeds in the region are generally well below this threshold, rarely exceeding it, with variation depending on the location and season (MRCC 2018). Undisturbed areas are less likely to produce windblown dust. However, based on the EPA AP-42 emissions factors, wind erosion of unpaved roads, agricultural activities, and heavy construction operations can occur at wind speeds above 12 mph, and dust events from construction materials typically occur at above 11 mph (EPA 1995). In the Wallula Maintenance Area for $PM_{10}$, the most recent exceedance events all occurred when the maximum 1-hour wind speed was above 29 miles per hour with a maximum speed of 55.7 miles per hour occurring in one instance (Ecology 2019). Appendix G provides more information on wind speeds and frequencies for a variety of regional monitoring sites.

***Volatile Organic Compound and Hazardous Air Pollutant Emissions***

VOCs are carbon-containing compounds such as propane, butane, and formaldehyde. VOCs form ground-level ozone by reacting with pollutants such as NOx and CO in the presence of sunlight (EPA 2017a). Ground-level ozone is a primary ingredient in “smog” and can cause or worsen a variety of respiratory health issues, including airway inflammation, coughing, asthma and bronchitis (EPA 2017a). VOC emissions in the Pacific Northwest are primarily generated by wildfires and other biogenic sources such as vegetation and soils. These sources account for 88 percent of VOCs in the region. The largest single anthropogenic source of VOCs in the Pacific Northwest was mobile vehicles, emitting about 5 percent of the total VOCs for the region (EPA 2017b).

There are 187 HAPs regulated by the EPA, including benzene, asbestos, and mercury compounds (EPA 2017c). People exposed to HAPs may experience increased risks of serious health effects, including cancer, immune system damage, and respiratory and neurological effects. Regional emissions of HAPs are primarily (87 percent) from biogenic sources (vegetation and soils) and fires (EPA 2017b). The largest anthropogenic source of HAPs is light-duty vehicles, emitting 4 percent of all HAPs in the Pacific Northwest (EPA 2017b).

#### *3.8.2.2 Greenhouse Gas Emissions*

GHGs trap heat in the Earth's atmosphere, contributing to the warming of the planet and shifting climate patterns. Some GHGs occur naturally in the atmosphere, such as water vapor, carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$), though human activities (such as the burning of fossil fuels for energy) increase their abundance. Other GHGs, such as fluorocarbons, are synthetic. GHGs are often measured in terms of their relative global warming potential (GWP). GWP communicates the relative contribution of a unit of a particular GHG to climate change. It is a measure of the radiative forcing of a GHG relative to $CO_2$ (Intergovernmental Panel on Climate Change 2014).[4]

Multiplying an amount of a GHG by its GWP allows for emissions to be expressed in terms of carbon dioxide equivalent ($CO_2e$). This calculation allows for comparison in like terms of the relative effects of various GHG emissions. It also allows for emissions of multiple types of GHGs to be summed and expressed in total.

While global climate change has regional impacts in the Pacific Northwest, the objective of GHG emissions reduction targets is to broadly reduce global GHG concentrations. At a national level, the primary source of GHG emissions is fossil fuel combustion for electricity generation and transportation. However, due to the prevalence of hydropower in the Pacific Northwest, regional GHG emissions from electric power generation are relatively low compared to the rest of the nation. This EIS focuses in particular on emissions from power generation and transportation sources because of the relevance of these activities to operations and management of Columbia River System projects. Chapter 4, *Climate*, includes discussion of the impacts of climate change.

**GREENHOUSE GAS EMISSIONS REGULATIONS AND MANAGEMENT**

There are no Federal regulations specifically focused on GHG emissions from power generation, although the EPA regulates certain GHG emission sources under the CAA.[5] Specifically, the EPA and the National Highway Traffic Safety Administration regulate the fuel efficiencies of light-duty vehicles (passenger cars and small trucks) via the Corporate Average Fuel Economy standards (EPA 2018h). GHG emissions are managed at state and local levels, however, via emissions reductions targets and sector-specific plans and policies.

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[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 $CO_2$ is one and GWPs of non-$CO_2$ GHGs are calculated relative to that of $CO_2$ (EPA 2018g). The GWP of $CH_4$ 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).

**State and Local Level Greenhouse Gas Emissions Reductions Targets**

Most Pacific Northwest states have set targets for reducing GHG emissions through regulatory, legislative, and public action. Despite relatively small emissions profiles compared to national averages, the emissions reduction targets set forth by state and local governments in the Pacific Northwest constitute considerable reductions in emissions by 2050 relative to 1990, as described in Table 3-197. The exception is Idaho, which has not identified emissions reduction targets at the state level. Both Oregon and Washington are members of the U.S. Climate Alliance, a bipartisan coalition of 23 governors (as of March 2019) committed to reducing GHG emissions consistent with the goals of the Paris Agreement.[6]

***Washington Emissions Reduction Targets***

Washington statewide GHG emission reduction targets commit Washington to reduce statewide emissions to 1990 levels by 2020 and to 25 percent below 1990 levels by 2035 (Washington State Legislature 2007). In 2016, the Washington Department of Ecology (Ecology) adopted the Clean Air Rule, which regulates carbon by placing a cap on emissions from large sources in the state (Ecology 2016). A March 2018 court ruling, however, suspended implementation of the Clean Air Rule pending review by the Washington Supreme Court (Ecology 2018).

In 2019, the Washington legislature passed the Clean Energy Transformation Act (Senate Bill 5116), which is focused on limiting GHG emissions from electricity consumption in Washington and targets emissions-free electricity by 2045. By 2025, the legislation prescribes that no coal costs can be included in utility retail rates (except decommissioning and remediation) and, beginning in 2030, requires that 80 percent of electricity sold by utilities comes from carbon-free source. The legislation requires that by 2045, 100 percent of the electricity supplied by utilities in Washington should be carbon-free.

***Oregon Emissions Reduction Targets***

The Oregon Legislature set a state target of reducing GHG emissions to 10 percent below 1990 levels by 2020 and 75 percent below 1990 levels by 2050 (House Bill 3543). In 2018, the Oregon Global Warming Commission's report to the legislature found that Oregon's GHG goals were not likely to be met with existing and currently planned actions in large part due to rising transportation-related emissions, despite having met its 2010 target (Oregon Global Warming Commission 2018).

***Montana Emissions Reduction Targets***

The state of Montana Department of Environmental Quality (MDEQ) published a Climate Change Action Plan in 2007 that outlined recommendations to reduce $CO_2$e emissions to 1990 levels by 2020 (MDEQ 2007a). No state regulations have been passed related to these goals 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.

#### ***Idaho Emissions Reduction Targets***

The state of Idaho has not announced an emissions reduction target; however, Idaho Power, the largest utility in the state, has set a goal of providing 100 percent clean energy by 2045. Another large utility, Avista, set a goal of being 100 percent carbon neutral by 2027 and 100 percent carbon-free by 2045.

**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<br>25% by 2035<br>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<br>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<br>10% by 2020<br>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 *(Goals not codified)* | Montana Climate Change Action Plan, 2007 |
| ID | No plan in place | | | | | |

1/ Production-based inventory measures GHG produced from activities within administrative boundaries whereas consumption–based emissions inventory measures GHG emitted in the production of goods (both within and outside of the administrative boundary) consumed within administrative boundaries.

**Local Emissions Reduction Targets – Municipalities and Counties**

Many Pacific Northwest cities and counties have also established targets for reducing GHG emissions. Three Montana mayors, 3 Idaho mayors, 13 Oregon mayors, and 11 Washington mayors are members of the Climate Mayors organization. Seattle and Portland are also members of the C40 cities, which is a network of global cities coordinating climate policy initiatives.

The City of Portland met its 2013 target of reducing emissions to 14 percent below 1990 levels (Multnomah County 2017), and has a goal of 80 percent reduction from 1990 levels by 2050. The cities of Eugene and Milwaukie in Oregon have goals to become carbon neutral by 2050 (Oregon Department of Energy 2018). King County, Washington's largest county, set emission reduction targets through a county-level climate action plan (King County 2015). Located in King County, Seattle's emissions reduction goals include being carbon neutral by 2050 (Seattle Office of Sustainability and Environment 2013). Appendix G includes a summary of county- and city-specific GHG emissions reductions initiatives.

**STATE RENEWABLE ENERGY TARGETS**

Oregon, Washington, and Montana have established renewable energy programs to promote growth in renewable energy sources. Renewable Portfolio Standards (RPS) require certain electric utilities to source a minimum percentage of the electricity sold to retail customers from eligible sources of renewable generation, such as solar or wind. These standards help increase the deployment of renewable power, and thus reduce emissions if they offset or replace electricity from GHG-emitting resources, such as a coal power plant.

RPS programs, which are designed to be forward-looking, generally do not allow older generating facilities, including existing hydropower, to be eligible. Many states, including Oregon and Washington, do allow incremental generation from efficiency upgrades at legacy hydropower facilities to qualify for RPS programs. The Western Renewable Energy Generation Identification System is the tracking system Western states use for all RPS-eligible renewable energy certificates (RECs) generated within the region. RECs are environmental commodities used to track the production and consumption of renewable electricity and its related attributes. Utilities use RECs to demonstrate compliance with RPSs as a REC represents 1 megawatt hour (MWh) of renewable electricity generated and delivered to the grid.

Table 3-198 summarizes the current level of renewable power (both with and without hydropower), as well as the current targets. The region is above the national average in terms of electricity generation from renewable sources. As previously described, not all hydropower is RPS eligible.

**Table 3-198. Percent of Electricity Produced from Renewable Sources and Hydropower, and 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)<br>50% (2040) |
| Washington | 77.5 | 8.8 | 15% (2020)[1/] |
| **National** | **14.9** | **8.4** | **N/A** |

Note: Data is only utility-scale generation (i.e., rooftop solar is not included). Some fraction of hydropower generation is RPS renewable; however, data is not available to describe the specific fraction that is eligible in each state.

1/ As noted in Section 1.2.1.1, the Washington Clean Energy Transformation Act, passed in 2019, specifies additional targets, including 100 percent renewable and non-emitting electricity by 2045.

Source: EIA (2017b); National Conference of State Legislatures (2018)

## NATIONAL GREENHOUSE GAS EMISSION LEVELS AND SOURCES

This section describes various national and state GHG emissions inventories and the different sectors that generate GHG emissions. Multiple entities catalog and create inventories of GHG emissions by state and source as a means to benchmark and track progress toward emissions reductions goals. The EPA manages the Inventory of U.S. Greenhouse Gas Emissions and Sinks (EPA GHG Inventory) and the Greenhouse Gas Reporting Program to track GHG emissions at the state and national level. Together, these inventories provide an overview of United States GHG emissions. Nationally, a larger portion of GHG emissions are from electricity generation, and a lesser portion from transportation, as compared to the Pacific Northwest.

### Greenhouse Gas Emissions from Energy

The EIA is a rich source of GHG emissions data associated with fossil fuel consumption and electric power generation and provides historical data that can be used to compare the country, states, and regions. The EIA calculates emissions from electric power generated within a state, not consumed within a state, as well as calculating emissions across consistent sectors in all states. The EIA calculates $CO_2$ emissions from the direct use of fossil fuels (e.g., residential gas heating) and primary fuels used for electricity production to the following “energy consuming” end user sources: commercial, electric power, industrial, residential, and transportation (EIA 2018c).

The EIA generally reports state-level energy-related emissions just for $CO_2$ and not for other GHGs. EIA describes that, “because energy-related carbon dioxide ($CO_2$) constitutes over 80 percent of total emissions, the state energy-related $CO_2$ emission levels provide a good indicator of the relative contribution of individual states to total greenhouse gas emissions” (EIA 2018c). Accordingly, this discussion of GHG emissions from fossil fuel consumption and electric power generation is specific to $CO_2$ emissions.

Considered by sector, there are few changes over the last 15 years in $CO_2$ emissions from energy-consuming sectors in the Pacific Northwest (all of Idaho, Montana, Oregon, and Washington). The transportation sector accounts for the largest share (50 percent in 2015) of total $CO_2$ emissions from energy-consuming sectors. In contrast, at the national level, the electric power sector is the highest emitting sector at 36 percent (EIA 2018b).[7] Figure 3-191 shows the breakdown of Pacific Northwest and national energy-related emissions by sector.

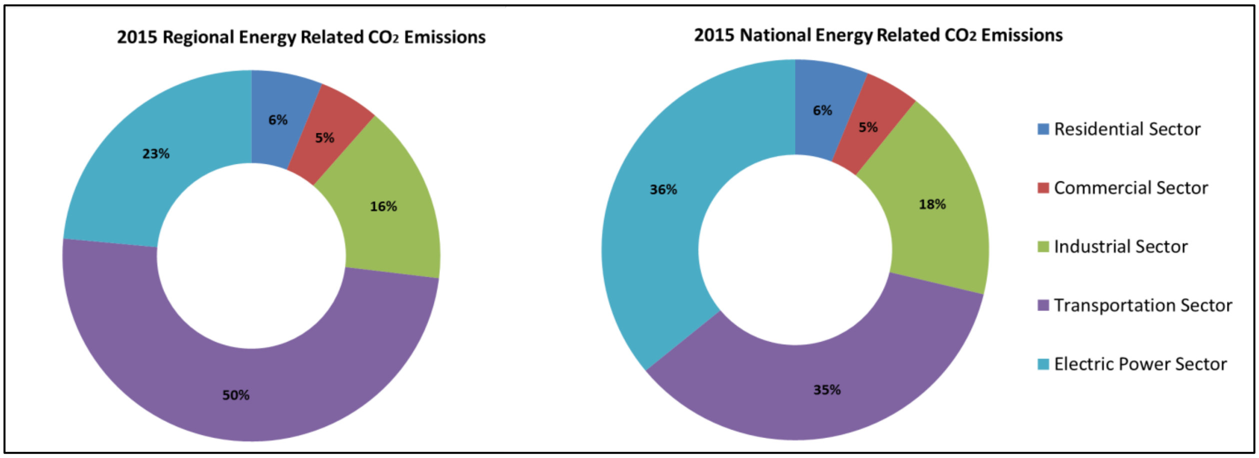


**Figure 3-191. Energy-Related $CO_2$ Emissions by Sector**
Source: EIA (2018b)

Given that economic activity and population influence total emission levels, it is useful to compare regional, state, and national emissions on a per-unit level. Comparing the region's $CO_2$ emissions per-capita or per-unit of economic output provides insight about the effects of net population migration and economic activity on the states' absolute (total) emissions numbers and demonstrates the relatively low emissions profile of the Pacific Northwest in comparison to the nation as a whole. States in the region have both low carbon intensities and low per-capita emissions based on EIA data, with the exception of Montana, which ranks above the national average in both measures. Per capita emissions, as well as the carbon intensity of the economy, are listed in Table 3-199.[8] The table includes the Pacific Northwest states and the national average for comparison. For both measures, the relative rank among states is listed, as well as the change over the last 15 years. Montana's per capita emissions are higher than the other states within the Pacific Northwest due to a larger portion of its electricity coming from coal 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.

**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%** |

Note: Carbon intensity is a ratio of grams of $CO_2$ emitted per dollar unit of gross domestic product. Per-capita emissions are expressed in metric tons per person. The state rankings identify the relative carbon intensity and per capita emissions across all 50 states, with 1 identifying the lowest levels.

Source: EIA (2018b)

### State-Level Greenhouse Gas Emissions Inventories

Another way to compare emissions is a consumption-based perspective, which is generally used for electricity and certain other sectors in state inventories, as opposed to the location where the emissions are generated (i.e., "production-based"), as described above for the EIA and EPA data. States often create GHG emission inventories to set emissions reductions goals, establish baselines, and catalog their emissions levels by sector and over time. Based on various GHG inventories, emissions in the Pacific Northwest are generally low compared to other states and national averages (EIA 2018d). This is in large part because of the abundance of hydropower in the region, which does not create GHG emissions when generating power (EIA 2017b). As such, electric power generation is not the largest GHG-emitting sector in the region as it is nationally.

Transportation accounts for the greatest share of GHG emissions in Idaho, Oregon, and Washington. Electric power generation is, however, associated with the greatest share of emissions in Montana where coal generation is relatively prominent (EIA 2018c). Each Pacific Northwest state has developed at least one GHG emissions inventory, which are described below. The state inventories described below use consumption-based accounting for the electricity sector, meaning electricity use is calculated based on where the electricity is consumed, not produced.

#### *Oregon and Washington Inventories*

Oregon and Washington inventories report GHG emissions, most recently in 2017 and 2013, respectively. Both inventories are created by state environmental agencies and evaluate multiple GHGs, which are then converted to $CO_2e$ for comparison by sector.

Oregon's total GHG emissions have declined from 70 million metric tons of $CO_2e$ (MMT $CO_2e$) in 2000 to 65 MMT $CO_2e$ in 2017 (Oregon Department of Environmental Quality [ODEQ] 2018a). In 2016, transportation (39 percent) and electricity use (26 percent) together account for the majority of emissions (ODEQ 2018a). Transportation emissions have stayed constant in Oregon at or around 24 MMT $CO_2$e since 2000, while electricity emissions fluctuated but have declined to about 16 MMT $CO_2$e from 23 MMT $CO_2$e since 2000.

In Washington, emissions were highest in 2000 at 110 MMT $CO_2$e but have remained between 90 and 100 MMT $CO_2$e for the last decade (Ecology 2016). In 2013, transportation (43 percent) and electricity use (19 percent) accounted for the majority of emissions (Ecology 2016). Emissions from other sectors (e.g., agriculture, industrial processes) have remained relatively constant in both Oregon and Washington (Ecology 2016; ODEQ 2018a).

***Idaho and Montana Inventories***

Idaho and Montana have GHG emissions inventories for the years from 1990 to 2005 with projections until 2020. In 2005, Idaho's total emissions were measured at 37.2 MMT $CO_2$e; the largest sector was transportation at 10.2 MMT $CO_2$e, or 27 percent of emissions (IDEQ 2008). Electricity emissions totaled 6.4 MMT $CO_2$e with 5.5 $CO_2$e coming from imported electricity. In Montana, the 2005 GHG inventory listed emissions of 36.8 MMT $CO_2$e in 2005 (MDEQ 2007b). The largest emitting sector was the electric sector at 10 MMT $CO_2$e, accounting for 27 percent of emissions; nearly all of the Montana electric sector emissions are from coal generation (MDEQ 2007b). Montana also exported electricity that accounted for another 9.4 MMT $CO_2$e, not considered in the Montana total. In both Idaho and Montana, emissions increased from 1990 to 2000 with the largest increases coming from transportation.

**Electricity Sector Greenhouse Gas Emissions**

The region has historically relied on hydroelectric power and fossil-fuel fired resources for most of its electric generation. Electricity production across the Pacific Northwest region produced 35 MMT $CO_2$e in 2016. On average, the $CO_2$e emission rate for coal power plants in the Pacific Northwest is 1,082 kg $CO_2$e/MWh, natural gas is 412 kg $CO_2$e/MWh, while the emissions rate for hydropower is 0 (EPA 2018e). Accordingly, emissions from electric power generation in the Pacific Northwest tend to fluctuate with the level of hydropower generation with years of poor water conditions leading to higher rates of emissions because fossil-fuel fired resources increase generation to make up for the decrease in hydropower generation (Herrera-Estrade et al. 2018).

At a national level, the average MWh of electricity produces roughly 450 kg $CO_2$e. In the Pacific Northwest, the average is as low as 85 kg $CO_2$e/MWh in Idaho and Washington and 139 kg $CO_2$e/MWh in Oregon. As discussed for the specific inventories, states with higher use of coal, such as Montana (average emissions of 571 kg $CO_2$e/MWh), have higher emissions from electricity production. States with higher use of hydropower and other low-carbon resources have lower emissions per MWh as can be seen in Idaho, Oregon, and Washington. Similarly, individual utilities vary in their use of various power generation resources and therefore have variable GHG emission profiles.

**Transportation Sector Greenhouse Gas Emissions**

As described above, the transportation sector is a major source of GHG emissions in the Pacific Northwest. Mobile vehicles including on-road vehicles, locomotives, marine and on-river vessels, and aircraft use a variety of fuels with varying GHG emission profiles. Generally, on-road vehicle gasoline is the largest contributor to transportation GHG emissions (Ecology 2016; ODEQ 2018). Diesel fuels, which can be used in heavy-duty trucks as well as locomotives and marine vessels, are the second largest contributor. For example, in the most recent Washington inventory, on-road gasoline and diesel vehicles emitted 28.72 MMT $CO_2$e compared to 3.36 MMT $CO_2$e for marine vessels and 0.86 MMT $CO_2$e for rail (Ecology 2016).

As compared with on-road vehicles, locomotives and marine vessels in the region contribute less to total GHG emissions. This difference is due to fewer ship and train miles travelled compared to passenger car and cargo trucks, as well as a higher efficiency per distance traveled in transporting either cargo or passengers as compared with on-road motor vehicles. Cargo trucks emit 7 times as much $CO_2$ per ton-mile compared to railroad and 10 times as much per ton-mile as compared with inland barges (154 grams per ton-mile compared to 21.2 and 15.6, respectively) (Kruse, Warner, and Olson 2017). Barge-based freight shipping is associated with the lowest GHG emissions profiles as compared with other modes of moving freight.

**Reservoir Methane Emissions from Hydropower Projects**

While hydropower-based power generation does not itself emit GHGs, GHG emissions are associated with hydropower construction and maintenance activities (e.g., use of vehicles and equipment). A recent publication by Deemer et al. (2016), which evaluated global reservoir data, states that artificial reservoirs created by dams can create substantial GHG emissions. Deemer et. al. describe that reservoirs result in flooding of large areas with organic matter that decomposes, consume oxygen, and convert the organic biomass to $CO_2$, $CH_4$, and NOx. If sufficient biomass and nutrients are available, natural breakdown of these substances can create an anoxic condition favorable to methane production.

Methane emissions from reservoirs take two dominant forms. During drawdown, emissions of methane can occur during degassing (diffusion) at turbines and spillways (Deemer et al. 2016). Drops in hydrostatic pressure during water level drawdowns can also enhance methane bubbling (ebullition) because decreased hydrostatic pressure enables bubbles to move upward easily and faster (Maeck, Hofmann, and Lorke 2014). In deeper water, less ebullition occurs because the bubbles are absorbed before reaching the air (Beaulieu et al. 2016; Falter 2017). Across studies in temperate zones, recorded methane emissions from ebullition are generally greater than recorded methane emissions from diffusion (e.g., Arntzen et al. 2013; Beaulieu et al. 2016, 2018). Across two eastern Washington reservoirs specifically, ebullition accounted for over 97 percent of methane emissions from the systems studied (Miller et al. 2017).

Conditions that promote methane emissions have been studied across reservoir sites. In general, methanogenesis depends on the availability of organic matter, which is then reduced under anaerobic conditions. Recent studies have associated $CH_4$ production with shallow depth systems, shallow (littoral) areas of reservoir systems, marshlands, embayments (coves), and stream deltas, which provide concentration points for organic matter and can positively influence methanogenesis (Bastviken et al. 2004; Demarty and Bastien 2011; West et al. 2012; Arntzen et al. 2013; Deemer et al. 2016; Falter 2017). Additionally, influx of organic and nutrient-rich material from urban and agricultural areas can cause additional decomposition and subsequent GHG emissions.

Reservoir characteristics and management practices can also influence methane emissions. Among others, Deemer et al. (2016) notes the many characteristics of reservoirs that that have been linked to the amount of methane emissions. These include age of the system, surface area, shoreline development, hydraulic retention time, lake level fluctuation, water circulation, winter ice cover, stratification, water temperature and transparency, etc. (see Appendix G for more detail on this factors). A recent study by Harrison et al. (2017) reviewed data for six Pacific Northwest reservoirs, identifying that reservoir drawdown affects the amount and timing of methane emissions. A global study by Ocko and Hamburg (2019) finds that the ratio of reservoir surface area to electricity generation, maximum temperate of the reservoir, and erosion rate of the reservoir are among the three best proxies for greenhouse gas emission potential.

Historically, estimating methane emissions at reservoirs has been challenging due to spatial and temporal heterogeneity. More recently, promising new measurement techniques provide more sophisticated options for capturing this variability (e.g., Beaulieu et al. 2016). However, limited application of these and other techniques to gather data to date hinders the ability to estimate methane emissions at each project site.

The literature identifies substantial methane emissions from hydropower projects in tropical climates, where a variety of factors, such as temperature, organic matter, and geology, generate higher emissions (St. Louis et al. 2000; Demarty and Bastien 2011). Additionally, recent studies at temperate reservoir sites, including in the United States and Europe, have shown non-negligible methane emissions levels, particularly from ebullition (e.g., Arntzen et al. 2013, Beaulieu et al. 2016, 2018, Bevelhimer et al. 2016, Del Sontro et al. 2010, Descloux et al. 2017). In response to Deemer et al. (2016), the Corps' Walla Walla District evaluated the potential for methane generation specifically from dams and reservoirs in the lower Snake River (Corps 2016a). The evaluation concluded that "for the relatively clean reservoirs of the Federal Columbia River Power System, which include the lower Snake River dams, conditions for low dissolved oxygen concentrations are not prevalent; thus methane gas is generally not an issue" (Corps 2016a).

The NW Council concluded that insufficient data was available to estimate reservoir methane emissions specifically for the Columbia River hydrosystem (NW Council 2017c). The NW Council also found that methane emissions at high levels are not likely due to the lower organic and nutrient loads to the system, and higher dissolved oxygen content (NW Council 2017). Appendix G, *Air Quality and Greenhouse Gas Emissions*, of this EIS further discusses reservoir methane emissions and the relevant literature.

**SOCIOECONOMIC IMPLICATIONS OF GREENHOUSE GAS EMISSIONS**

GHG emissions influence a variety of socioeconomic outcomes related to climate change, including agricultural productivity, human health, flood risk, and infrastructure and fishery damages. The value of reducing levels of GHGs in the atmosphere is the avoided damages that would be generated by a unit of GHG if it were present. Economists express this value in monetary terms representing society's willingness to pay to avoid climate-related impacts associated with an additional unit of a GHG in the atmosphere. This value is defined as the "social cost" of GHGs. The more common term, "social cost of carbon" (SCC), generally pertains to $CO_2$ emissions.

Social costs are generally presented under multiple different scenarios according to different future carbon distribution scenarios (e.g., average, higher-than-expected) and discount rate assumptions. The distributions in the value of the social costs reflect the uncertainty associated with the calculation of marginal climate-related impacts. The social cost values grow over time, reflecting growth in incremental damages as the magnitude of climate-related damages increases. Because GHGs affect climate change and associated socioeconomic impacts at a global level, social cost of GHG metrics are generally presented as global measures of socioeconomic impact, independent of the geographic source of the emissions.

The academic literature and Federal agency guidance on these measures is actively evolving. A Federal interagency working group on the social cost of GHGs formerly issued guidelines that were updated over time (the most recent was in August 2016) to help agencies assess the climate change–related benefits of reducing carbon emissions and integrate these estimates into their assessments of regulatory impacts in cost-benefit analyses (Interagency Working Group on Social Cost of Greenhouse Gases, United States Government 2016). The interagency guidance provided a SCC dollar value based on the average of three integrated assessment models. The socioeconomic effects of changes in emissions are calculated by multiplying the change in emissions in a given year by that year's SCC value. The net present value of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across affected years.

In January 2017, a National Academy of Sciences report recommended changes in the framework being used by Federal agencies for estimating the social cost of GHGs to improve transparency and better reflect uncertainty. Particular issues highlighted were: (1) the selection of appropriate discount rates for intergenerational effects of climate change; (2) best methods for reflecting uncertainty related to climate change and economic growth projections; and (3) appropriate consideration of global versus domestic societal benefits of avoided damages.

In March 2017, Executive Order 13783 on Promoting Energy Independence and Economic Growth withdrew the Interagency Working Group's technical documents related to measures of the SCC generally used by Federal agencies for policy analysis. As of January 2019, no formal Federal agency guidance regarding social cost of GHG metrics exists. At the state level, however, the Washington Utilities and Transportation Commission recently directed utilities to evaluate the monetary costs associated with GHG emissions using the former interagency working group guidance (Washington Utilities and Transportation Commission 2018).

The literature identifies an average social cost per ton of carbon dioxide of $42 for the year 2020 (2007 dollars, assuming a discount rate of 3 percent), though the value varies between $12 per ton and $123 dollars per ton depending on the carbon distribution scenario and discount rate assumption (Marten et al. 2015). There are differences in the social cost measures for different GHGs because of differences in the "global damage potential" of the GHGs. While global warming potential of GHGs account for the differences in radiative forcing of the gases as compared with $CO_2$, global damage potential captures the differences across gases in terms of climate-related damages.

### 3.8.3 Environmental Consequences

This section evaluates how the CRSO EIS alternatives may affect air quality and greenhouse gas (GHG) emissions. The section also discusses the potential for health and environmental effects of air quality changes, and the socioeconomic implications of the changes in GHG emissions. The analysis relates the findings of other resource analyses in this EIS, to the consequent effect on air pollutant and GHG emissions, including Section 3.7, *Power Generation and Transmission*, and Section 3.10, *Navigation and Transportation*.

Table 3-200 provides an overview of the effect determinations.[9] Overall, air quality and GHG emissions would most likely improve relative to 2016 conditions under the No Action Alternative.

Table 3-200 identifies the effects of the MOs relative to the No Action Alternative. Cumulative effects including air quality are discussed in Chapter 6. Analysis of the preferred alternative is included in Chapter 7. The loss of emissions-free hydropower generation in MO1, MO3, and MO4 has the potential to degrade air quality and increase GHG emissions and criteria pollutant emissions by increasing fossil fuel generation. However, current trends towards decarbonization may lead to the replacement of some or all of the reductions in hydropower generation with zero-emitting power resources. If the reduction in hydropower generation is replaced by zero-emitting power resources, then MO1 would likely have negligible to minor beneficial effects on air quality and GHG emissions by reducing fossil fuel generation relative to the No Action Alternative. Under MO2, the increased hydropower generation has the potential to offset fossil fuel generation, reducing overall electricity-sector emissions and resulting in minor beneficial effects to air pollutant emissions, air quality, and GHG emissions. Under MO3 and MO4, however, the reduction in hydropower would most likely increase reliance of the energy sector on fossil fuels to meet demand regardless of the types of replacement resources 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.

generation would still be needed to provide power during peak loads (e.g., winter cold snaps and summer heat waves). Further, MO3 would increase vehicle traffic due to limitations on navigation in the lower Snake River. Potential future coal plant retirements are a key source of uncertainty in this analysis with implications on the ability to replace the loss of hydropower generation with zero-emitting resources. Section 3.8.3.3, *Multiple Objective Alternative 1*, therefore includes an analysis that considers how potential future coal plant retirements may affect this analysis.

**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 | **Short-term, minor adverse effects in Region D:** Construction-related air pollutant emissions due to multiple structural projects at McNary Dam.<br>**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. | **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. |
| MO2 | **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.<br>**Short-term, minor adverse effects in Region C:** Potential for localized fugitive dust emissions at Dworshak Dam due to reduced reservoir water levels. | **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. |

| Alternative | Air Quality Effects | GHG Emissions Effects |
|---|---|---|
| MO3 | **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.<br>**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. | **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.<br>**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. |
| MO4 | **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.<br>**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. | **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.<br>**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. |

Note: These effects reflect the base case power analysis, which accounts for the retirements of Colstrip 1 and 2 but not all recently announced coal power plant closures. See the Methodology below and the power analysis (Section 3.7) for further details.

#### *3.8.3.1 Methodology*

This analysis undertakes a qualitative assessment of the expected effects of the MOs on air quality. Similarly, analysis of GHG emissions effects from construction activities and other sources (e.g., reservoir methane and exposed sediment) is qualitative. Where potential air quality and greenhouse gas emissions effects are tied to a specific region (Regions A-D), it is specifically discussed within the analysis.

However, as electricity-sector GHG emissions are a focus of evolving regulatory and policy initiatives in the Pacific Northwest, this analysis quantifies the effects of the MOs on GHG emissions from power generation. Additionally, as the transportation sector is a key source of regional GHG emissions, this analysis conducts a quantitative analysis of the expected effects of the alternatives on navigation- and transportation-related GHG emissions.

Effects of the MOs are characterized as beneficial or adverse, as defined by the magnitude of effect classifications. The analysis considers context, intensity, and duration to determine whether effects are negligible, minor, moderate, or major. The intensity of effects for air quality considers whether criteria air pollutant changes are likely to exceed *de minimis* emissions as defined by the EPA.[10] For other non-criteria air pollutants, the analysis references the relative change in the emitting activities as compared with the No Action Alternative (e.g., the changes in power generation from coal and natural gas power plants).

**ANALYTICAL APPROACH FOR AIR QUALITY EFFECTS**

**Power Generation**

Sulfur dioxide ($SO_2$), carbon monoxide (CO), nitrous oxides ($NO_x$), particulate matter (PM), HAPs, and VOCs are air pollutants that are directly emitted from fossil fuel combustion. This analysis provides a qualitative assessment of the expected direction (beneficial or adverse) and magnitude of changes in air quality resulting from electricity generation in the Pacific Northwest based on several factors:

- Locations of emissions (context): Determining the implications of the emissions changes on ambient air quality requires referencing the geographic locations of the emissions sources, and comparison with the existing ambient air quality and sensitive areas in those regions under the No Action Alternative (e.g., presence of nonattainment or maintenance areas for criteria pollutants, or presence of protected scenic areas ).
- Changes in the fuel mix (intensity): Evaluating the magnitude of the emissions changes requires understanding how the MOs differ from the No Action Alternative with respect to the relative level of generation from fossil fuel-based sources over time.
- Timeframe of emissions effects (duration): Generally, the changes in the fuel mix, and associated emissions effects under the alternatives, would be long-term effects expected to persist into the foreseeable future.

For alternatives that may adversely affect air quality, the analysis considers the potential for effects on human health and ecological resources. This assessment references the available 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.

**Navigation and Transportation**

Emissions related to barge, truck, and rail transport of goods include criteria pollutants, as well as HAPs and VOCs. The navigation and transportation emissions analysis references Section 3.10, which describes the effects of the alternatives on modes (barge, rail, truck) of freight transport, focusing on the lower Snake and lower Columbia Rivers. The analysis considers where changes in barge, road, and rail transport would occur (context), the level of change relative to the No Action Alternative (intensity), and the timeframe over which the changes are expected (duration) to qualitatively evaluate the potential emissions effects of modal shifts in freight transportation.

**Construction Activities**

The use of construction equipment and vehicles to implement structural measures, such as dam breaching or fish passage improvements, results in air pollutant emissions. In accordance with EPA guidance, qualitative analysis of the potential effects on air pollutant emissions and ambient air quality considers the duration of equipment use, amount of equipment (context), and area of construction activities (intensity) (EPA 1995). Construction work typically results in localized air pollutant emissions, such as PM. Therefore, the analysis focuses on qualitatively assessing and describing potential air pollutant changes and air quality effects in and around construction sites. Additionally, construction-related emissions are short term, occurring during the construction and maintenance activities.

**Other Air Pollutant Emissions Sources**

This analysis qualitatively evaluates the potential for windblown fugitive dust from exposed sediment, based on expected reservoir elevation changes at the CRS projects, including the timing of these changes (context and duration). Specifically, the H&H analysis (Section 3.2) quantifies how the water levels would change at each CRS project, and this analysis assesses the potential for additional sediment to be exposed and suspended by wind (intensity). Additionally, the analysis considers the potential for fugitive dust from exposed lakebeds under MO3. High-wind dust events, as defined by recent EPA exceptional events guidance, involve sustained wind speeds of 25 miles per hour (mph). Based on the EPA AP-42 emissions factors, fugitive windblown dust from wind erosion of unpaved roads, agricultural activities, and heavy construction operations can occur at wind speeds above 11 mph, with larger particles settling very close to the source. Using these thresholds, this analysis examines meteorological data at several affected regional locations to assess potential fugitive dust effects under each alternative.

**ANALYTICAL APPROACH FOR GREENHOUSE GAS EMISSIONS EFFECTS**

**Power Generation**

As described in Section 3.7, *Power Generation and Transmission*, hydropower, which does not generate GHG emissions, currently provides over half of the electricity generation in the Pacific

Northwest. The MOs would affect the amount of hydropower produced by the CRS projects due to the operational and structural measures and, under MO3, dam breaching. This, in turn, would affect the fuel mix (i.e., relative contribution of generation from fossil fuels, hydropower, and other renewables) and, therefore, regional electricity-sector GHG emissions. As the power system in the Pacific Northwest is part of a broader electricity market across much of the western United States, the analysis additionally considers how changes in generation in the Pacific Northwest may result in shifting generation—and associated GHG emissions—across the Western Interconnection area (as described in Section 3.7).

The assessment of the context and intensity of the GHG emissions effects is based on model outputs. The emissions estimates from electricity generation for the year 2022 are an output of the AURORA power markets model employed in the power analysis (Section 3.7). The model incorporates power plant specific emissions factors from the EPA Clean Markets data to estimate carbon dioxide ($CO_2$) emissions associated with the modeled power generation mix. AURORA calculates emissions based on the site of power production instead of location of consumption. For example, power generated in Washington that is consumed in California is attributed to electricity-sector emissions in Washington, not California. While AURORA only reports $CO_2$ emissions, not other GHGs, $CO_2$ is the primary source of GHG emissions from power generation, accounting for over 80 percent of energy-related emissions (EIA 2018). Thus, this analysis focuses specifically on $CO_2$, noting that this approach may err on the side of understating total GHG emissions changes associated with the MOs. Assessing the intensity of the GHG emissions effects of the MOs, considers that the quantified changes in carbon emissions are likely understated.

The emissions outputs from AURORA for MO1, MO3, and MO4 consider two separate assumptions for how alternative sources of power generation (i.e., resource replacement) offset the expected reductions in hydropower generation from the CRS projects, to meet demand for electricity. The resource replacement analysis, described in more detail in Section 3.7, considers two alternative assumptions to illustrate the range of potential outcomes. One relies on "conventional least-cost" resource replacement, which, for each of the alternatives in this analysis, is natural gas. The second, "zero-carbon," assumes a combination of renewables and demand-response measures are used to maintain the reliability of the electricity system.[11] Recent and emerging policy to reduce electricity-sector GHG emissions in the Pacific Northwest, indicates that the zero-carbon resource replacement portfolio may better reflect future trends.

Of note, even under the zero-carbon resource replacement portfolio, natural gas and coal generation from existing plants may increase relative to the No Action Alternative. This may 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.

dispatchable, whereas hydropower and fossil fuel generation can be readily ramped up to meet spikes in demand.

As MO2 results in improved reliability of the electricity system as compared with the No Action Alternative, replacement resources are not necessary. For MO2, the AURORA model emissions results accordingly reflect the potential for the increased hydropower generation to offset the need for fossil fuel generation, reducing overall electricity-sector emissions.

As described in Section 3.7, the power analysis forecasts power rates over a 20-year timeframe (2022 to 2041). The emissions analysis relies on AURORA outputs identifying the effects of the alternatives on the fuel mix in year 1 (2022) under each alternative, and then accounts for expected changes in generation by fuel type, described over time by the Northwest Power and Conservation Council Midterm Assessment and Seventh Power Plan (NW Council 2016b).[12]

For each alternative, this analysis reports average emissions from power generation in year 2022, as reported by the AURORA model in total million metric tons of carbon dioxide (MMT $CO_2$)—including total emissions and the change relative to the No Action Alternative—for both the Pacific Northwest and across the broader Western Interconnection electricity market.[13] The analysis also presents estimated emissions changes (MMT $CO_2$) over the 20-year period of analysis for power effects (2022 to 2041).

Future coal plant retirements are a source of uncertainty for this analysis. The “base-case” (i.e., the emissions effects analysis described throughout this section) assumes continued emissions from coal plants that are expected to be operating in 2022. While coal generation declines slightly over time (at an average annual rate of 0.65 percent) according to the NW Council forecast, the 20-year analysis does not incorporate now planned and potential future additional coal plant retirements that were not known at the time the NW Council forecast was developed.[14]

Given that state and local decarbonization policies are changing the generation portfolio in the region and across the Western Interconnection area into the 2020s and beyond, this base case, which was established for power effects modeling in 2017, no longer reflects the current understanding of the power sector over time. Accordingly, additional analysis is included to understand the implications that additional coal retirements would have on power generation and associated GHG emissions. Specifically, the analysis considers additional scenarios

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[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.

reflecting "limited coal retirement" (representing an additional 2,505 MW of coal compared with the No Action Alternative) and "no coal" (all coal is retired). This analysis is included in the power and transmission effects analysis (Section 3.7.3) and additionally incorporated in this air quality and GHG emissions analysis, as described under the No Action Alternative analysis in Section 3.8.3.2.

**Navigation and Transportation**

Section 3.10 describes potential changes in navigation and transportation associated with the alternatives. The analysis considers where changes in barge, road, and rail transport would occur (context), the level of change relative to the No Action Alternative (intensity) and the timeframe over which the changes are expected (duration) to evaluate the potential emissions effects of modal shifts in freight transportation. For MOs that affect changes in ton-miles of freight transport by trucks, rails, and/or barges, this analysis applies average emissions factors (described in Section 3.8.2) to quantify the GHG emissions effects.

**Construction Activities**

Like the air pollutant emissions, analysis of construction-related emissions is based on qualitative assessment of the extent and duration of equipment use under each alternative. GHG emissions from construction-related activity are very limited as compared with the electricity-sector emissions.

**Other Greenhouse Gas Emissions Sources**

The analysis considers other potential sources of GHG emissions, including methane from reservoirs as well as the carbon sequestration potential of the landscape (e.g., due to changes in the land area that is submerged under the reservoirs). As described in Section 3.8.2.2, a recent study by the Corps' Walla Walla District, concluded that hydropower projects in the lower Snake River, as well as the Columbia River System as a whole, generally do not release methane gas due to the high oxygen and circulation levels and relatively low organic matter in the system (Corps 2016a). This analysis therefore finds that potential effects of the alternatives on reservoir methane emissions are negligible for all alternatives; a discussion of this assessment is included in Appendix G.

**Meeting Emissions Reductions Targets**

Section 3.8.2.2 and Appendix G describe state and local GHG emissions reductions targets, including those related specifically to the energy sector as well as more broadly across the economy. For each alternative, this analysis relates how the GHG emissions changes under each alternative would affect the states and municipalities' efforts to meet these targets.

**Social Cost of Carbon**

GHG emissions influence a variety of socioeconomic outcomes related to climate change, including agricultural productivity, human health, flood risk, and infrastructure and fishery damages. This analysis monetizes these socioeconomic implications in terms of the best available information on SCC values. SCC values vary by year reflecting incremental growth in climate-related damages over time.

This analysis applies year-specific social cost of carbon dioxide (SC-$CO_2$) values based on the August 2016 Technical Support Document developed by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) to calculate the monetized value of incremental changes in $CO_2$ emissions over time (2022 to 2041) (IWG 2016). Although the IWG developed the SC-$CO_2$ estimates for use in the context of regulatory impact analysis and not NEPA analysis, and this Technical Support Document (IWG 2016) was withdrawn by Executive Order, it is useful to consider these values in context of the CRSO EIS because the SC-$CO_2$ values are frequently referenced in the context of Pacific Northwest emissions reductions targets and, in particular, currently used by the Washington Utilities and Transportation Commission to evaluate changes in GHG emissions.

Appendix G provides the full SCC analysis, as summarized for each of the alternatives in this section. The results of the SCC analysis are the present value and annualized value of changes in GHG emissions in the Pacific Northwest for each action alternative as compared with the No Action Alternative. While the emissions sources described in this analysis are located in the Pacific Northwest, the SCC values reflect global benefits of avoided climate-related damages due to the reduced $CO_2$ emissions. According to best practices for acknowledging the considerable uncertainty associated with these estimates, this analysis additionally presents four alternative scenarios for the SC-$CO_2$ based on alternative discount rate assumptions, and expected temperature effects of atmospheric carbon.

#### *3.8.3.2 No Action Alternative*

Under the No Action Alternative, operations of the CRS projects would continue based on operation rules as of September 2016. The operations from 2016 onward include management of the 14 CRS projects consistent with previous biological opinions, planned maintenance in future years (e.g., including Grand Coulee Dam overhaul plus forthcoming upgrades to McNary and Ice Harbor Dam turbines), and regional load and power resource forecasts.

As previously described, the effects of the alternatives on power generation in the Pacific Northwest is the primary driver of the air pollutant and GHG emissions changes in this analysis. The base-case scenario for this analysis (consistent with the base-case power generation analysis described in Section 3.7.3) finds that emissions from power generation will reflect continued coal and natural gas-based generation. Emissions are expected to be relatively constant over time under the No Action Alternative, with slight reductions due to a slight decrease in reliance on coal, but slight increase in reliance on natural gas.

As previously noted, a key uncertainty of this analysis is the effect of recent legislation focused on limiting GHG emissions from electricity consumption in Washington. The 2019 Clean Energy Transformation Act (SB 5116) prescribes that no coal costs be included in utility's retail rates (except for decommissioning and remediation) by 2025. The base penalty is $100 per MWh, and varies depending on resource type, for failure to comply. Starting in 2030, the legislation requires that 80 percent of energy sold by utilities be from carbon-free sources. It is the policy of the state that by 2045, 100 percent of energy sold by utilities should be carbon free. In addition, the Oregon Clean Energy and Coal Transition Act (2016) mandates the elimination of the cost of coal resources in retail rates of investor-owned utilities by 2030.

The legislation in Washington and Oregon, among other regional GHG emissions reductions initiatives, reduces the likelihood of new fossil fuel plant construction in Washington and Oregon, and increases uncertainty regarding how the electricity sector will evolve over the coming decades under the No Action Alternative, as well as the MOs.

Under the No Action Alternative, effects to air quality are anticipated to be similar in the Canadian portions as those described in the United States. However, the effects would reduce as the geographic distance from the CRS projects increase.

**AIR POLLUTANTS AND AIR QUALITY UNDER THE NO ACTION ALTERNATIVE**

As described in Section 3.8.2, the Pacific Northwest generally experiences good air quality. Recent years have seen reductions in fossil fuel-based electricity generation that emits pollutants and total air pollutant emissions from on-road vehicles have decreased over the last 10 years (EPA 2018c). However, wildfires are a key source of air pollutant emissions (particularly PM) in the region.

**Air Pollutant Emissions from Power Generation under the No Action Alternative**

Air pollutants from power generation would be reduced from current levels under the No Action Alternative. For 2022, the expected fuel mix includes a reduction in fossil fuel-based generation, specifically coal. Coal is the largest contributor of air pollutants from the energy sector and existing forecasts expect a reduction in coal generation by 2032 under the No Action Alternative (EPA 2018c; NW Council 2019). If additional coal plant retirements occur in the future, this would further improve air quality over time under the No Action Alternative.

Given the decrease in coal generation, air pollutant emissions under the No Action Alternative, especially $SO_2$, would decrease. As coal generation is reduced, generation increases from natural gas sources (which emit air pollutants at a much lower rate than coal power) and wind and solar, which do not generate air pollutant emissions (NW Council 2019). The emissions rate of $SO_2$ for natural gas is less than 1 percent of the $SO_2$ emissions from coal per MWh (Oak Ridge National Laboratory 2017). Ozone ($O_3$) and its precursor emissions ($NO_x$, CO, and VOCs), would also decrease as coal-fired power plants emit roughly five times more $NO_x$ and CO than natural gas.

The reduction in $SO_2$ and ozone-precursor emissions may have beneficial health and ecological effects. $SO_2$ exposure can lead to adverse respiratory effects such as bronchoconstriction and decreased lung function. $O_3$ irritates the respiratory system, reduces lung function, and can damage cells lining the lungs. Deposition of $SO_2$ on ecosystems results in acidification, excess nutrient enrichment, increased mercury methylation, and ultimate mercury contamination. $O_3$ is also harmful to plants, causing cellular damage and plant death.

Due to the recent legislation focused on reducing carbon from the electricity sectors over the longer term in Washington and Oregon, the adoption of wind, solar, and other replacement resources that do not emit air pollutants may increase and, therefore, electricity-related air pollutant emissions would continue to decrease. The health and ecological benefits of the reduced air pollutant emissions would be concentrated in the areas where the coal power plants are currently located. These areas include portions of Region D near the Boardman coal power plant in Oregon, as well as near Centralia in Lewis County, Washington, northwest of Region D.

**Air Pollutant Emissions from Navigation and Transportation Activities under the No Action Alternative**

As described in Section 3.10, the navigation and transportation activity most relevant to this analysis is freight transport. Regionally, the air pollutant emissions from commercial marine transportation (which includes shipping along the lower Snake and lower Columbia Rivers) are a small fraction of emissions for most air pollutants from navigation and transportation, ranging from 4.7 percent of $NO_x$ to as low as 0.1 percent of CO (EPA 2017). However, marine vessels do emit large quantities of $SO_2$, and contribute over three quarters of regional transportation-related $SO_2$ emissions. Light-duty vehicles also emit HAPs.

The navigation and transportation analysis does not identify shifts in freight transport under the No Action Alternative over time (i.e., no modal changes expected). However, there is potential for additional clean fuel standards, such as the Cleaner Trucks Initiative. The Cleaner Trucks Initiative does not have specific public targets yet but signaled the intent to update $NO_x$ standards for trucks in early 2020 (EPA 2018c). The Washington State Clean Fuels Standard, which did not pass, would have targeted a reduction in GHG emissions of 10 percent by 2028 and 20 percent by 2025 (Washington State Legislature 2019a). While this does not directly target air pollutants, reducing GHG emissions results in co-benefits of reduced air pollutant emissions. Should standards like these pass, a reduction in air pollutant emissions from navigation and transportation sector under the No Action Alternative may occur.

**Air Pollutant Emissions from Construction Activities under the No Action Alternative**

The No Action Alternative includes nine project-specific structural measures that have the potential to generate air pollutant emissions from use of construction equipment. Most of these projects are complete or will be completed in 2019 (e.g, John Day adult PIT antennas in 2016–2017 and the Lower Granite PIT monitoring in 2019). The other structural measures in the No Action Alternative occur at Bonneville and Little Goose. Bonneville, in Region D, would have gatewell improvements at the second powerhouse. Little Goose, in Region C, would have a spillway weir gate hoist installed, as well as adult ladder improvement.

The emissions from construction activities include PM from disturbing roadways and other criteria pollutant and HAPs emissions from the burning of fuel for equipment and vehicles.

In addition, crushing and grinding operations associated with construction can generate PM, solid particles and liquid droplets suspended in air (EPA 2018a). Such pollutants irritate the eyes, nose, and throat, and carry toxic metals. Exposure to PM is associated with health effects, especially those with already diminished pulmonary or cardiac capacities and young children; including aggravated asthma, bronchitis, and irregular heartbeats. However, given the short-term nature and limited geographic scope of these effects around the project site, the emissions effects are most likely minor under the No Action Alternative. Moreover, construction-related BMPs may avoid or minimize the potential adverse effects of air pollutants from construction activities. Construction-related BMPs include minimizing dust becoming airborne (e.g., watering surfaces, applying dust suppressants, laying gravel); managing vehicle emissions and dust (e.g., restricting speeds, using paved roads, reducing idle times); and direct emissions management (e.g., replacing outdated equipment, installing emissions reductions technologies, using ultra-low sulphur fuel for off-road equipment) (Western Regional Air Partnership 2006; EPA 2010; Corps 2014). These guidelines provide practices for ensuring efficient fuel use and protection of the surrounding populations and habitat.

**Other Air Pollutant Emissions Sources under the No Action Alternative**

If reservoir levels are lowered for extended periods, fugitive dust emissions may be a concern. Fugitive dust results in localized air quality effects based on which reservoirs experience elevation changes (San Joaquin Valley 2011). Adverse health and environmental consequences can occur from intense concentrated dust events, particularly if there are any contaminated sediments suspended (EPA 2017). However, Section 3.3.3, *River Mechanics*, finds that shoreline exposure effects, and the potential for changes in the reservoir elevation at CRS projects, are negligible under the No Action Alternative. By extension, this analysis expects negligible associated air quality effects.

**GREENHOUSE GAS EMISSIONS UNDER THE NO ACTION ALTERNATIVE**

Power generation is the primary source of GHG emissions of relevance to this EIS. In accordance with the multiple state and local-level initiatives to reduce GHG emissions from electricity generation, changes in the fuel mix over time under the No Action Alternative are most likely to favor low-carbon resources, such as solar and wind, as well as demand -response measures.

**Greenhouse Gas Emissions from Power Generation under the No Action Alternative**

The AURORA model outputs identify total $CO_2$ emissions from power generation in the Pacific Northwest of approximately 36.7 MMT $CO_2$ 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

generated in the region. The 90 percent confidence interval for emissions from AURORA is 29 to 45 MMT $CO_2$.

Estimates of the monthly mean $CO_2$ emissions from the AURORA power model range from 0.81 to 2.6 MMT $CO_2$. Over the course of the year, December has the highest total GHG emissions while June has the lowest due to changes both in monthly hydropower generation and in average monthly demand for electricity. Given that hydropower generation increases in the spring months due to greater water supply from snowmelt runoff, fossil fuel generation can decrease during those months. The emissions trend depicts the decrease in use of coal and natural gas sources for generation in the spring months (April, May, June).

Under the base case for the No Action Alternative, predicted regional emissions would be relatively steady at these levels over time, reflecting continued generation from coal and natural gas resources, constant hydropower, and new renewable power. This is based on the forecast of the generation fuel mix over time described in the Seventh Power Plan and Midterm Assessment, which describes that average annual generation from coal would decrease over time at a rate of 0.65 percent and average annual generation from natural gas would increase over time at a rate of 0.87 percent (NW Council 2016b, 2019).

However, as previously described, recent and emerging policy focused on reducing energy-sector GHG emissions may influence how power is generated over time under the No Action Alternative. For example, the Washington Clean Energy Transformation Act includes increasing price penalties per MWh of fossil fuel generation in Washington. By 2045, all Washington utilities must sell carbon-free power, likely increasing renewable generation and reducing emissions over time. Additionally, the Oregon Clean Energy and Coal Transition Act (2016) requires eliminating the cost of coal resources in retail rates of investor-owned utilities by 2030. Of note, however, some level of fossil fuel generation is expected as other states within the region (e.g., Montana and Idaho[16]) are not currently planning emissions reductions targets at the level of Washington and Oregon.

Specifically, retirements of coal-fired power plants would reduce GHG emissions because coal is the largest emitter of GHGs per MWh of all power generation types. This analysis finds that the forecast of GHG emissions under the No Action Alternative and the MOs is very sensitive to assumptions regarding the future availability of coal resources and the future fuel mix. The power analysis presents results of an analysis that considers alternative assumptions regarding the level of coal capacity available to serve regional loads and the amount of zero-carbon resources needed to maintain that ability to serve regional loads. As described in more detail in Section 3.7.3, the analysis considers two possible future conditions: (1) "limited coal" reflects closure of most, but not all, coal plants (1,741 MW of coal

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2016b, 2019). Over the last 3 years of available data, the EPA estimated Jim Bridger emitted an average of 14.2 MMT $CO_2$, and 900,000 tons of $CO_2$ 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 $CO_2$) 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/).

remaining) and (2) "no coal" reflects complete elimination of all coal capacity (0 MW of coal remaining).

Because coal combustion results in the greatest level of GHG emissions per unit of power generated, energy sector GHG emissions in the Pacific Northwest would be lower under either of the future coal conditions. The specific magnitude of emissions reductions under the "limited coal" and "no coal" conditions is uncertain and depends on the extent to which sufficient renewable resource capacity may be added to the system to replace the reduction in coal. Regional GHG emissions would be considerably lower if renewable resources that do not generate emissions replace the coal. However, if the reduction in coal capacity results in some increase in fossil fuel-based generation (e.g., natural gas), the emissions reduction benefit would be less.

Coal, along with natural gas and hydropower, are considered "dispatchable" resources, meaning they can generally be used to generate power that is then delivered on demand to meet market needs. However, with the exception of hydropower, these power resources generate GHG emissions. Solar and wind resources do not generate emissions but are also generally not dispatchable without a source of storage as their ability to generate power relies on external factors (i.e., sufficient sun and wind). Thus, a reduction in dispatchable coal capacity under the No Action Alternative, and the added loss in dispatchable hydropower under MO1, MO3, and MO4, would result in the need for a large amount of additional renewable power resources to meet regional power reliability standards, as described in Section 3.7.3 and Appendix G. As described in Section 3.7, *Power Generation and Transmission*, electricity generation and consumption in the Pacific Northwest is part of a broader market that spans much of the western United States. Therefore, this analysis also considers GHG emissions across the broader Western Interconnection area. Changes in generation in the Pacific Northwest may result in shifting generation more broadly across the Western Interconnection area. Under the No Action Alternative, average annual emissions from electricity generation across the Western Interconnection area under the base case are 163 MMT $CO_2$.

The Western Electricity Coordination Council 2028 Anchor Data Set provides the best available information on potential changes to the power system over time for the entire Western Interconnection area. As with the Pacific Northwest, emissions are likely to decrease over time due to power plant retirements and their replacement with renewable power (WECC 2019). The net effect over the next 10 years is a reduction in high emitting power, such as coal, and replacement with natural gas and non-emitting renewables, decreasing overall energy-sector GHG emissions.

**Greenhouse Gas Emissions from Navigation and Transportation under the No Action Alternative**

The primary commodity that relies on navigation by barge on the Snake River that may be affected by the MOs is wheat, which is being transported primarily to regional ports for export. Under the No Action Alternative, barge traffic remains the primary transportation method for wheat at 1.1 billion ton-miles expected in 2022 (Section 3.10). Rail and truck move 820 million and 460 million ton-miles of wheat, respectively. The emissions from all three modes of freight transportation for wheat in the region are expected to be 0.11 MMT $CO_2$ in 2022. Truck transportation is the main source of emissions at 68 percent. Barges account for 16 percent of the expected emissions, despite carrying five times more freight than trucks. Rail accounts for the remaining 16 percent of emissions. These emissions represent less than 1 percent of regional transportation-related $CO_2$ emissions.

As previously mentioned, uncertainty exists regarding the future levels of emissions from the transportation sector under the No Action Alternative. In 2019, Washington tried but failed to pass a clean fuel standard. Oregon already has a clean fuels standard in place targeting a 10 percent reduction by 2026 (ODEQ 2018b).

**Greenhouse Gas Emissions from Construction**

As previously described, structural measures for No Action Alternative that could generate GHG emissions from construction activity largely have been or will be completed in 2019. These activities would likely involve construction vehicles and equipment to remove outdated equipment or structures, and construct improvements. The duration of construction projects for these structural measures would determine how much fuel is combusted. Construction equipment tends to use diesel fuel, which generates more GHG than regular gasoline, and off-road equipment is often less efficient than on-road vehicles (EPA 2018d).

Implementation of the structural measures in No Action Alternative does not involve forecasting construction equipment use over extended periods of time. BMPs for reducing emissions, as previously described, may reduce the intensity of these activities and, given the limited level future construction activity under the No Action Alternative, construction-related GHG emissions are likely negligible.

**Other Greenhouse Gas Emissions Sources under the No Action Alternative**

As previously described, hydropower projects in the lower Snake River and lower Columbia River generally do not release methane gas from the reservoirs due to the high oxygen and circulation levels and relatively low organic matter in the system (Corps 2016). This is not expected to change over time under the No Action Alternative.

**Meeting Emissions Reductions Targets under the No Action Alternative**

In Washington, the GHG emissions reduction target for all sectors is 25 percent below 1990 levels by 2035, and for Oregon the target for 2050 is 75 percent below 1990 levels. Both states also have 2020 target goals (reaching 1990 levels for Washington and 10 percent below 1990 levels for Oregon). Section 3.8.2 provides additional details on state level targets and Appendix G lists regional county or local level targets.

The trends under the No Action Alternative for reduced electricity-sector carbon emissions are beneficial for meeting overall GHG emissions reductions targets. However, further reductions in emissions would be required to meet the state targets and the Washington Clean Energy Transformation Act than the reductions forecast under the No Action Alternative base case.

**Social Cost of Carbon under the No Action Alternative**

The SCC analysis quantifies the value of the change in emissions relative to No Action Alternative. For comparison with the quantified changes, however, this analysis finds that the total electricity-sector emissions in the Pacific Northwest over a 20-year time period (2022 to 2041), result in a present value cost of $31 billion (assuming a 3 percent discount rate).

**SUMMARY OF EFFECTS**

Air pollutants from power generation would be reduced from current levels under the No Action Alternative, assuming a continued reduction in coal generation. Additional clean fuel standards could lead to a decrease in emissions associated with transportation and navigation activities. The No Action Alternative includes nine project-specific structural measures that have the potential to generate air pollutant emissions from use of construction equipment. Under the base case for the No Action Alternative, predicted regional emissions would be relatively steady at these levels or reduced relative to 2016 levels over time, reflecting continued generation from coal and natural gas resources, constant hydropower, and new renewable power.

### *3.8.3.3 Multiple Objective Alternative 1*

MO1 includes various structural and operational measures that have the potential to affect regional air pollutant and GHG emissions. Operational measures in MO1, including various water management changes such as modifying draft rates and manipulating reservoir levels, have the collective effect of reducing the overall level of hydropower generation in the region. This would result in the need for power replacement resources that affect energy-sector air pollutant and GHG emissions. Additionally, structural measures such as modifications for spillways and other upgrades at the CRS projects would require construction that generates short-term emissions during the construction period.

Under MO1, effects to air quality are anticipated to be similar in the Canadian portions as those described for the United States. However, the effects would reduce as the geographic distance from the CRS projects increase.

**AIR POLLUTANTS AND AIR QUALITY UNDER MULTIPLE OBJECTIVE 1**

**Air Pollutant Emissions from Power Generation under Multiple Objective Alternative 1**

Under MO1, average generation from hydropower in the Pacific Northwest in 2022 is approximately 1 percent less than under the No Action Alternative (based on AURORA model outputs). The consequences of this for air pollutant emissions depend on resource replacement assumptions. Under the conventional least-cost resource replacement portfolio, increased generation from natural gas would increase air pollutant emissions, in particular $NO_x$ and to a lesser degree $SO_2$ and PM, near the sites of the generation resources. Given that natural gas generation increases by 2.4 percent in the Pacific Northwest under MO1, criteria pollutant emissions would likely increase slightly as compared to No Action Alternative. The changes in air pollutant emissions would occur primarily in Region D near McNary Dam as the increased natural gas generation would likely be focused in that area (Section 3.7, *Power Generation and Transmission*). Any additional fossil fuel generation would be subject to and controlled by the applicable emissions permitting and regulation as described in Section 3.8.1. There are no nonattainment areas for $O_3$ or $O_3$ precursors in this area, and the increase in natural gas is unlikely to risk adherence to NAAQS or reach EPA *de minimis* thresholds.

However, under the zero-carbon resource replacement portfolio, focused primarily on increasing generation from solar projects, air pollutant emissions experience a slight decrease relative to No Action Alternative. This is due to a reduction in natural gas generation of 3.6 percent relative to No Action Alternative because the added solar power capacity additionally reduces some natural gas generation. As previously described, recent and emerging policy focused on reducing energy sector GHG emissions indicates that the zero-carbon resource replacement portfolio may better reflect future trends. Thus, the effects of MO1 on air pollutant emissions from power generation may be beneficial due to the slight reduction in fossil fuel combustion.

**Air Pollutant Emissions from Navigation and Transportation under Multiple Objective Alternative 1**

MO1 would not affect the level of barge transportation or river navigation in the region; thus, this analysis does not expect effects on navigation and transportation-related air pollutant emissions. As described in Section 3.10.3, changes to the cost of shipping on the Columbia and Snake Rivers under MO1 would be less than 1 percent, and the changes to river flows would be minimal.

**Air Pollutant Emissions from Construction Activities under Multiple Objective Alternative 1**

Structural measures under MO1 include upgrading weirs, lamprey modifications, and improving turbines. The structural measures are focused in Region C and D at Bonneville, McNary, and John Day Dams, and the lower Snake River projects. Construction activities involving additional vehicle and equipment use would result in additional pollutant emissions. These construction activities include new passage routes for fish at McNary and Ice Harbor, as well as modifications and additions to other fish bypass structures. The magnitude of these construction activities varies but all would require machinery and equipment as well as vehicle travel to the site, which increase air pollutants, especially PM, relative to No Action Alternative.

In addition, construction of replacement power resources (natural gas or solar power plants) under MO1, would result in vehicle and equipment-related emissions. Solar power does not produce air pollutants when generating, but has the potential to produce pollutants, specifically PM, from construction activities and construction vehicles travelling on unpaved roads (EPA 2017). Both resource replacement portfolios would have short-term and localized adverse effects due to increased air pollutants relative to No Action Alternative, though the exact location of these potential power generation resources and hence pollutants is uncertain.

Overall under MO1, implementation of the structural measures and construction of replacement resources would increase air pollutant emissions. These emissions would be localized to the project site and short term; occurring during the period of construction.[17] Of note, certain construction activities, specifically at McNary and Ice Harbor Dams (Regions C and D) would occur in proximity to the Wallula maintenance area for $PM_{10}$. Adoption of BMPs (as previously described) to reduce PM emissions from construction activities may mitigate adverse effects.

**Other Air Pollutant Emission Sources under Multiple Objective Alternative 1**

Relative to the No Action Alternative, reservoir levels under MO1 would fluctuate more than 2 feet at four CRS projects (Dworshak, Grand Coulee, Libby, and Hungry Horse Dams), resulting in exposed sediment during drawdown operations. Exposed sediment could become suspended PM under certain conditions, such as high temperatures, a lack of precipitation, and wind erosion. The River Mechanics analysis (Section 3.3.3.5) considers the change in the amount of time that elevations remain at low levels under MO1, and determined this impact would be negligible; therefore, this analysis likewise finds a negligible effect on air quality. In addition, the wind speeds at nearby regional monitoring sites are relatively low compared to the speed threshold for windblown dust, making the potential for fugitive dust and high-wind dust events relatively low. Appendix G provides more information on wind speeds and frequencies.

**GREENHOUSE GAS EMISSIONS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 1**

Generally, the direction of effect on GHG emissions (beneficial or adverse) from the various sources mirrors the direction of the effect on air pollutant emissions. Under the conventional least-cost resource replacement portfolio, emissions would increase slightly, whereas under the zero-carbon resource replacement portfolio, emissions would decrease slightly relative to the No Action Alternative. Short-term increases in GHG emissions from construction-related activities would most likely be negligible.

**Greenhouse Gas Emissions from Power Generation under Multiple Objective Alternative 1**

MO1 would result in a reduction in hydropower generation. As described in Table 3-201, this analysis estimates $CO_2$ emissions from power generation under MO1 according to both the conventional least-cost and zero-carbon resource replacement portfolios, as well as for the Pacific Northwest and the broader Western Interconnection area. For the conventional least-cost power portfolio, emissions would be 37.0 MMT $CO_2$ in 2022 across the Pacific Northwest, a less than 1 percent increase from the No Action Alternative. However, given that policy and legislative decisions in Oregon and Washington are targeting large reductions in GHG emissions,

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[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.

a 1 percent increase in GHG emissions under the conventional least-cost power portfolio makes this goal more difficult to achieve. These changes are due to an increase in natural gas generation. Under the zero-carbon portfolio, emissions would be 36.2 MMT $CO_2$ in 2022, a roughly 1 percent reduction in overall emissions as compared with the No Action Alternative. These changes are due to reductions in natural gas generation and increased solar generation.

As previously described, recent and emerging policy focused on reducing energy-sector GHG emissions indicates that the zero-carbon resource replacement portfolio may better reflect future trends. The near-term effect of the reduction in hydropower, should the new replacement resources not be built by 2022 as assumed, would likely be an increase in generation and emissions from existing fossil-fuel power plants.

**Table 3-201. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple 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 |

Note: Pacific Northwest estimates include Jim Bridger and half of the North Valmy 2 coal power plants. The conventional least-cost resource replacement portfolio relies primarily on natural gas generation to replace foregone hydropower, whereas the zero-carbon resource replacement portfolio relies primarily on generation from solar resources.

Source: AURORA outputs; see Section 3.7, *Power Generation and Transmission,* for modeling approach.

Like the No Action Alternative, emissions over time under MO1 remain relatively steady reflecting the NW Council forecast for generation over time (NW Council 2016b). The effects of MO1 on $CO_2$ emissions as compared with No Action Alternative remain modest over the 20- year timeframe (1 percent increase in emissions assuming conventional least-cost natural gas replacement, and 1 percent decrease in emissions assuming zero-carbon renewable resource replacement), as highlighted in Table 3-202.

**Table 3-202. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple Objective Alternative 1 (2022 to 2041)**

| Alternative (Resource Replacement Portfolio) | Emissions (MMT $CO_2$) | | | | |
|---|---|---|---|---|---|
| | 2022 | 2027 | 2032 | 2037 | 2041 |
| No Action Alternative<br>Total Emissions in the Pacific Northwest | 36.7 | 36.6 | 36.5 | 36.5 | 36.5 |
| MO1 (Conventional Least-Cost)<br>Increase Relative to No Action Alternative | 0.34<br>*(0.9%)* | 0.37<br>*(1.0.%)* | 0.38<br>*(1.0%)* | 0.39<br>*(1.1%)* | 0.39<br>*(1.1%)* |
| MO1 (Zero-Carbon)<br>Decrease Relative to No Action Alternative | -0.48<br>*(-1.3%)* | -0.45<br>*(-1.2%)* | -0.47<br>*(-1.3%)* | -0.48<br>*(-1.3%)* | -0.48<br>*(-1.3%)* |

As described in Section 3.7.3.2, the power analysis is sensitive to alternative assumptions regarding coal capacity in the region. Under a limited or no coal future, as described above, the emissions effects under MO1 relative to the No Action Alternative would depend on the nature of replacement resources (fossil fuel and renewable resources) for both the reduction in coal and the reduction in hydropower. If the reduction in coal were replaced by zero-carbon resources, emissions could decrease substantially; however, the amount of zero-carbon resources required would be very substantial, particularly due to the reduction in hydropower under MO1, as presented in Table 3-203. This analysis additionally considers potential emissions effects across the wider Western Interconnection area (excluding areas outside of the United States) due to the interconnectedness of the electricity markets (as described in Section 3.7.2). Average emissions reported by the AURORA model according to the conventional least-cost replacement portfolio for MO1 would be 156 MMT $CO_2$ across the Western Interconnection area; this would be a 0.4 percent increase as compared with No Action Alternative emissions over the same area. In the Western Interconnection area for the zero-carbon resource replacement portfolio, average emissions would be 155 MMT $CO_2$, an approximately 0.1 percent reduction in total emissions. The slightly more modest changes in emissions across the broader Western Interconnection area relative to the change in the Pacific Northwest indicate that the effects of MO1 are focused in the Pacific Northwest.

**GHG Emissions from Navigation and Transportation under Multiple Objective Alternative 1**

MO1 would not affect the level of barge transportation or river navigation in the region; thus, this analysis does not expect effects on navigation and transportation-related GHG emissions. As described in Section 3.10.3, changes to the cost of shipping on the Columbia and Snake Rivers under MO1 would be less than 1 percent, and the changes to river flows would be minimal.

**GHG Emissions from Construction Activities under Multiple Objective Alternative 1**

Construction activities associated both with the structural measures described under MO1 and construction of replacement resources for the reduction in hydropower generation have the potential to generate GHG emissions. The use of light- and heavy-duty vehicles and equipment rely on combustion of diesel fuel or gasoline.

Emissions from construction and operations of power plants, when considered with the emissions resulting from power generation, are commonly referred to as "lifecycle" GHG emissions. For natural gas and other fossil fuels, lifecycle emissions are primarily from fuel combustion for power generation. However, for renewable energy resources that do not emit GHGs as a byproduct of power generation, overall lifecycle emissions are low and primarily linked to construction and other industrial processes to build the resource (NREL 2013).

Overall, construction-related GHG emissions under MO1 would be short term (during the construction period) and minor as compared with the changes in emissions from power generation under this alternative.

**Other GHG Emissions Sources under Multiple Objective Alternative 1**

As previously described, the MOs would not affect reservoir methane emissions. Additionally, MO1 would not result in any changes in land use (e.g., conversion from inundated to vegetated landscapes) that would affect carbon sequestration potential of the landscape.

**Meeting Emissions Reductions Targets under Multiple Objective Alternative 1**

This analysis evaluates implications on emissions according to both the conventional least-cost and zero-carbon replacement portfolios. As previously described, recent and emerging policy focused on reducing energy-sector GHG emissions indicates that the zero-carbon resource replacement portfolio may better reflect future trends. The zero-carbon resource replacement portfolio would result in a very modest reduction in GHG emissions under MO1 relative to No Action Alternative, aiding the states and municipalities in achieving emission goals. However, this would also require more zero-carbon resource acquisitions for MO1 than for the No Action Alternative to achieve the states' goals.

**Social Cost of Carbon Effects under Multiple Objective Alternative 1**

This analysis estimates the monetized value of the $CO_2$ emissions from power generation in term of the social costs (i.e., climate-related damages) of the marginal changes in atmospheric carbon. Under MO1, the conventional least-cost resource replacement portfolio (mostly natural gas generation) would result in a slight increase in $CO_2$ emissions relative to No Action Alternative, whereas the zero-carbon replacement portfolio (mostly solar generation) would result in a slight decrease in emissions.

Assuming the zero-carbon replacement portfolio is reflective of future trends, the central estimate for the present value (2022 to 2041) of the reduced emissions benefit under MO1 is $400 million (assuming a 3 percent discount rate in accordance with best practices) (IWG 2016). This equates to an annualized benefit of $25 million. These benefits reflect the global reduction in climate-related damages associated with the expected reduction in GHG emissions under MO1 if the additional zero-carbon generation is constructed to replace lost hydropower generation. The SCC for the conventional least-cost replacement portfolio is presented in

Table 3-203. Appendix G includes the calculation of the emissions and SCC values by year over the timeframe of the analysis.

Table 3-203 presents a range of results reflecting alternative assumptions regarding the appropriate discount rate for discounting these types of intergenerational effects, as well as a portfolio that considers greater than expected (95th percentile) damages from climate change over time. Due to the considerable uncertainty inherent in the calculation of the SCC values, the results of the analysis according to all of these alternative assumptions are presented for consideration.

**Table 3-203. Present Value and Annualized Values of Changes in $CO_2$ Emissions in the Pacific Northwest under Multiple Objective Alternative 1 Relative to No Action Alternative (2022 to 2041, 2019 U.S. Dollars)**

| Alternative (Resource Replacement Portfolio) | | Social Cost of Carbon Values | | | |
|---|---|---|---|---|---|
| | | 5% Average | 3% Average | 2.5% Average | 3% 95th 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 |

Note: These estimates reflect three different discount rates (the averages used by three different climate models) and a high estimate of the 95th percentile for potential lower-probability, high-impact outcomes to capture uncertainty. The central estimate is the 3 percent discount rate. All values in this table are rounded to two significant digits. Full values for each portfolio as well as the schedule for each discount rate SCC estimates are in Appendix G. Annualized values are calculated by first estimating the total present value of the future stream of costs and then calculating the annualized estimates (i.e., average annual equivalent) employing the same discount rate assumption.

Source: IWG 2016: for SCC cost schedule over time, see Appendix G for full schedule.

## SUMMARY OF EFFECTS

For all of the regions, air pollutant emissions from power generation would most likely be reduced as compared with No Action Alternative due to increased reliance on renewable resources and a reduction in fossil fuel generation (assuming zero-carbon resource replacement). Changes in emission from navigation and transportation and fugitive dust would be negligible relative to No Action Alternative. Construction-related emissions would be short term, and limited to the construction period. These effects are also localized at various CRS project sites, and potential construction sites for new power generating resources in uncertain locations. Further, in Region D, multiple structural projects at McNary may result in PM and other air pollutant emissions nearby an existing maintenance area for PM emissions, though the increased emissions are unlikely to exceed *de minimis* standards and risk the attainment status of this maintenance area. Overall, effects of MO1 on air quality would be generally negligible, except for minor short-term adverse effects in Region D by McNary Dam.

If reduced hydropower generation is replaced with zero-carbon resources, then air pollutant emissions from power generation would most likely be reduced as compared with No Action Alternative due to increased reliance on renewable resources and a reduction in fossil fuel generation. This would result in a modest reduction in GHG emissions. If conventional least-cost resources, specifically gas-fired generation, replace reduced hydropower generation, then carbon emissions would likely increase slightly. Changes in emission from navigation and transportation would be negligible relative to No Action Alternative. Construction-related GHG emissions would increase under MO1, but that would be short-term (during the construction period) and very limited as compared with the reductions in emissions from power generation under this alternative. Overall, given the benefit associated with reduced GHG emissions effects of MO1, there would potentially be beneficial impacts to GHG emissions assuming a zero-carbon replacement portfolio ranging to minor adverse effects across the region.

#### *3.8.3.4 Multiple Objective Alternative 2*

**AIR POLLUTANTS AND AIR QUALITY UNDER MULTIPLE OBJECTIVE ALTERNATIVE 2**

MO2 would increase hydropower generation thus reducing fossil fuel generation. These increases in hydropower are due to operational measures, such as ending summer spill in August. The increased hydropower generation would offset the need for fossil fuel generation, resulting in a lesser level of air pollutant emissions in the region relative to No Action Alternative. No construction of major replacement resource occurs, and structural measures would not generate major increases relative to No Action Alternative.

Under MO2, effects to air quality are anticipated to be similar in the Canadian portions as those described for the United States. However, the effects would reduce as the geographic distance from the CRS projects increase.

**Air Pollutant Emissions from Power Generation under Multiple Objective Alternative 2**

No replacement power would be necessary under MO2 because this alternative results in improvements in system reliability. The increases in hydropower under MO2 would decrease natural gas and coal power generation relative to the No Action Alternative, reducing air pollutants. Overall, these changes would increase hydropower generation by approximately 3 percent and reduce coal and natural gas by 56 average megawatts (aMW) and 190 aMW, respectively. This represents an approximately 5.7 percent decrease in coal and natural gas power generation.

These changes in the fuel mix reduce air pollutant emissions from power generation. Reductions in $SO_2$ emissions (a common air pollutant generated from the combustion of coal and, to a lesser degree, natural gas) around the coal and gas plants is possible. These power plants are primarily located in Region D. The reduced air pollutant emissions from coal generation would occur outside of the Pacific Northwest, in Montana and eastern Wyoming where the Colstrip and Jim Bridger coal power plants are located.[18] Locations are in proximity to nonattainment areas for PM (Colstrip) and $O_3$ (Jim Bridger). Thus, the reduction in air pollutant emissions in these areas may confer a benefit in helping meet and maintain NAAQS.

**Air Pollutant Emissions from Navigation and Transportation under Multiple Objective Alternative 2**

MO2 would not affect the level of barge transportation or river navigation in the region; thus, this analysis does not expect effects on navigation- and transportation-related air pollutant emissions. As described in Section 3.10.3, changes to the cost of shipping on the Columbia and Snake Rivers under MO2 would be less than 1 percent, and the changes to river flows would be minimal.

**Air Pollutant Emissions from Construction Activities under Multiple Objective Alternative 2**

Structural measures under MO2 include upgrading spillway weirs to adjustable spillway weirs, expanding lamprey structures, and installing pumps. The upgrading of spillway weirs occurs at five CRS projects, concentrated at McNary and John Day Dams. Other structural measures include building powerhouse and spill surface passage routes at the Ice Harbor, McNary, and John Day projects. Multiple modifications to existing projects also occur under MO2 and, though these are less intensive construction activities than upgrading or installing new facilities, they may also generate adverse pollutant effects relative to No Action Alternative. MO2 would not require any replacement power resources and therefore would not result in additional power plant construction activity, as compared with No Action Alternative.

The construction activities in MO2 would occur primarily in Regions C and D, in proximity to the Wallula maintenance area for $PM_{10}$. Adoption of BMPs to reduce PM emissions from construction activities (as previously described) could mitigate adverse effects. Air pollutant emissions from construction activities under MO2 would have short-term, localized effects occurring during the period of construction at projects primarily in Regions C and D.

**Other Air Pollutant Emissions Sources under Multiple Objective Alternative 2**

Under MO2, due to increased draft for hydropower generation, elevations at multiple CRS projects would decrease compared to No Action Alternative, exposing additional shoreline. The River Mechanics analysis (Section 3.3.3.5) determined that the effects of these elevation changes would be negligible apart from at Dworshak Dam in Region C. Reservoir elevation levels at Dworshak Dam would change by more than 20 feet in March through May relative to the No Action Alternative. Under high temperature and wind, and low precipitation conditions, the exposed sediment may increase fugitive windblown dust and associated PM emissions. The average wind speeds and $95^{th}$ percentile wind speeds for regional monitoring stations near 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.

dust events, making the likelihood of fugitive dust emissions low. Appendix G provides more information on wind speeds and frequencies.

The potential for increased dust at Dworshak may occur seasonally over the long term and may be mitigated, for example by watering these areas. The effects would be localized to the project site, which is not located near or within existing PM maintenance or nonattainment areas. Effects from potential windblown dust could affect the Nez Perce Tribe, as the Nez Perce Reservation is near Dworshak.

### GREENHOUSE GAS EMISSIONS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 2

MO2 would result in additional hydropower generation as compared with No Action Alternative. The increased hydropower generation displaces fossil fuel-based generation resulting in a net decrease in GHG emissions from power generation relative to No Action Alternative. All other effects of MO2 would most likely be negligible relative to this decrease.

#### Greenhouse Gas Emissions from Power Generation under Multiple Objective Alternative 2

$CO_2$ emissions from power generation in the Pacific Northwest under MO2 would be 35.9 MMT $CO_2$ in 2022, a 2.2 percent reduction from No Action Alternative in that year. This beneficial effect of the alternative is due to more hydropower generation and less use of natural gas and coal relative to No Action Alternative. As MO2 would increase hydropower generation, it does not require replacement resources. Table 3-204 and Table 3-205 presents the total Pacific Northwest power generation-related emissions compared to No Action Alternative and identifies emissions effects of MO2 over the 20-year timeframe.

**Table 3-204. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple 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 |

Note: Pacific Northwest estimates include Jim Bridger and half of the North Valmy 2 coal power plants. See footnote 16 for further description of these power plants .MO2 does not experience a loss of hydropower and does not have resource replacement portfolios. Therefore, this table presents only a single portfolio relative to No Action Alternative.

Source: AURORA outputs; NW Council (2019)

**Table 3-205. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple 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%)* |

As described in Section 3.7.3.2, the power analysis is sensitive to alternative assumptions regarding future coal capacity in the region. Under a limited or no-coal future, the emissions effects under MO2 would depend on the nature of replacement resources (fossil fuel and renewable resources) for the reduction in coal. If the reduction in coal were replaced by zero-carbon resources, emissions could decrease substantially; however, the amount of zero-carbon resources required would be large (though relatively smaller than the No Action Alternative due to the increase in hydropower under MO2) as presented in Table 3-205 and 3-206. The increased hydropower generation under MO2 would offset at some level the need for additional zero-carbon resources in the region.

Across the Western Interconnection, excluding regions outside of the United States, average emissions from AURORA under MO2 are 161 MMT $CO_2$, a 1.1 percent reduction from No Action Alternative. The more modest changes in emissions across the broader Western Interconnection area indicate that the effects of the alternative are focused in the Pacific Northwest.

**Greenhouse Gas Emissions from Navigation and Transportation under Multiple Objective Alternative 2**

MO2 does not affect the level of barge transportation or river navigation in the region; thus, this analysis does not expect effects on navigation- and transportation-related GHG emissions. As described in Section 3.10.3, changes to the cost of shipping on the Columbia and Snake Rivers under MO2 would be less than 1 percent, and the changes to river flows would be minimal.

**Greenhouse Gas Emissions from Construction Activities under Multiple Objective Alternative 2**

GHG emissions from construction activities under MO2 would likely be negligible. MO2 includes some structural measures that would increase use of vehicles and equipment relative to No Action Alternative; however, this effect would be short term (during the construction period) and minor. Additionally, MO2 does not include construction of any replacement power generating resources.

**Other Greenhouse Gas Emissions Sources under Multiple Objective Alternative 2**

MO2 would not affect reservoir methane emissions. Additionally, MO2 would not result in any changes in land use (e.g., conversion from inundated to vegetated landscapes) that would affect carbon sequestration potential of the landscape.

**Meeting Emissions Reduction Targets under Multiple Objective Alternative 2**

MO2 would increase hydropower generation across the Pacific Northwest, reducing fossil fuel generation and associated emissions as compared with No Action Alternative. In particular, MO2 would be beneficial to GHG reduction targets that are consumption based, as it reduces emissions from high coal generation areas such as Montana and Wyoming. While Montana does not have a specific emissions target, much of the coal generation is exported to Washington and Oregon for consumers. In addition, while Oregon is not expected to meet short-term emissions targets, Oregon would experience the largest decreases in GHG emissions under MO2 of any Pacific Northwest state. The decrease would be very limited (0.1 MMT $CO_2$) at the state level. However, for municipalities such as Beaverton in Washington County and Portland in Multnomah County that have high targets by 2050, these emissions reductions may be meaningful since these municipalities' power is supplied by IOUs that currently have substantial fossil fuel generation in their portfolios.

**Social Cost of Carbon Effects under Multiple Objective Alternative 2**

MO2 would reduce emissions relative to No Action Alternative. Appendix G includes the calculation of the emissions and SCC values by year over the timeframe of the analysis. The central estimate for the present value (2022 to 2041) of the reduced emissions benefit under MO2 is $950 million (assuming a 3 percent discount rate in accordance with best practices) (IWG 2016). This equates to an annualized benefit of $62 million. These benefits reflect the global reduction in climate-related damages associated with the expected reduction in GHG emissions under MO2. While these values seem large, they reflect a relatively limited reduction in GHG emissions (3.0 percent) relative to No Action Alternative over the 20-year timeframe.

Table 3-206 presents a range of results reflecting alternative assumptions regarding the appropriate discount rate for discounting these types of intergenerational effects, as well as a portfolio that reflects greater than expected (95th percentile) damages from climate change over time. Due to the considerable uncertainty inherent in the calculation of the SCC values, the results of the analysis according to these alternative assumptions are presented for consideration.

**Table 3-206. Present Value and Annualized Values of Changes in $CO_2$ Emissions in the Pacific Northwest under Multiple Objective Alternative 2 Relative to No Action Alternative (2022 to 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% 95th |
|---|---|---|---|---|---|
| MO2 | Total | -$240 million | -$950 million | -$1,500 million | -$2,900 million |
| | Annualized | -$18 million | -$62 million | -$91 million | -$190 million |

Note: These estimates reflect three different discount rates (the averages used by three different climate models) and a high estimate of the 95th percentile for potential lower-probability, high-impact outcomes to capture uncertainty. The central estimate is the 3 percent discount rate. All values in this table rounded to two significant digits. Full values for each portfolio as well as the schedule for each discount rate SCC estimates are in Appendix G. Annualized values are calculated by first estimating the total present value of the future stream of costs and then calculating the annualized estimates (i.e., average annual equivalent) employing the same discount rate assumption.
Source: IWG 2016; for SCC cost schedule over time, see Appendix G for full schedule

**SUMMARY OF EFFECTS**

For all regions, increased power generation from hydropower (no associated emissions) would reduce generation from fossil fuels, leading to a reduction in emissions (including PM, $NO_x$, and $SO_2$). Changes in emissions from navigation and transportation would be negligible relative to No Action Alternative. MO2 includes a relatively low level of construction activity given no new power generation resources would be needed to meet regional demand for power.

In Region C, potential exists for seasonal, localized fugitive dust emissions at Dworshak over the long term due to reduced water levels. However, these emissions would not be near or within existing nonattainment or maintenance areas and may be mitigated by watering exposed sediment and limiting vehicle use in the exposed sediment areas. Overall, effects of MO2 on air quality would be minor beneficial across all regions with the exception of minor adverse effects in Region C near Dworshak Dam.

Increased power generation from hydropower (no associated emissions) would reduce generation from fossil fuels, leading to a reduction in GHG emissions. Changes in emissions from navigation and transportation, as well as construction activities, would be negligible relative to No Action Alternative. Construction-related GHG emissions under MO2 would be short term (during the construction period), and very limited as compared with the reductions in emissions from power generation under this alternative. Overall, GHG emissions effects would be beneficial and minor under MO2.

#### *3.8.3.5 Multiple Objective Alternative 3*

MO3 involves the breaching of the lower Snake River projects (Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam). The breaching of these projects would reduce hydropower generation, increasing regional air pollutant and GHG emissions. MO3 also requires extensive deconstruction work that would create air pollutant emissions from construction activities and equipment. Compared to No Action Alternative, air pollutants and GHG emissions would increase under MO3.

Under MO3, effects to air quality are anticipated to be similar in the Canadian portions as those described for the United States. However, the effects would reduce as the geographic distance from the CRS projects increase.

**AIR POLLUTANTS AND AIR QUALITY UNDER MULTIPLE OBJECTIVE ALTERNATIVE 3**

Under MO3, air pollutant emissions would increase from the energy sector regardless of the resource replacement portfolio. Additionally, construction activities and exposed shoreline sediment under MO3 would affect air pollutant emissions and may result in negative effects on air quality under MO3 as compared to No Action Alternative. The breaching of the lower Snake River projects is the primary measure affecting air pollutants.

**Air Pollutant Emissions from Power Generation under Multiple Objective Alternative 3**

With the foregone power generation from the lower Snake River projects, hydropower generation would decrease by 9 percent relative to No Action Alternative. Emissions would increase under both the conventional least-cost and zero-carbon replacement portfolios. The conventional least-cost resource replacement portfolio would result in additional natural gas and coal power generation in the Pacific Northwest, an increase of 28 percent and 7 percent, respectively. The zero-carbon resource replacement portfolio would include considerable additional generation from solar resources; however, the level of solar included does not enable the system to meet demand at all times (e.g., during peak demand). Consequently, even under the zero-carbon replacement portfolio, gas generation would increase by 3 percent and coal by 8 percent, resulting in additional air pollutant emissions from these sources.[19] In addition, any additional fossil fuel generation would be subject to and controlled by the applicable emissions permitting and regulation as described in Section 3.8.1. The potential exists for changes to affect regional haze and deterioration of air quality even if new emissions do not violate these standards. Chapter G-4 of Appendix G describes regional haze in further detail.

The increased air pollutant emissions under MO3 relative to No Action Alternative, particularly $NO_x$ emissions, would most likely be concentrated in Region D in Oregon, where the natural gas power plants may be located (Section 3.7, *Power Generation and Transmission*).

The large increase in natural gas-based power production in these areas would be a concern mainly due to $NO_x$ emissions. These emissions could pose a risk to air quality by increasing concentrations of $NO_2$ in the local vicinity. Also, $NO_x$ is a precursor to $PM_{2.5}$ and ozone. No areas in the near vicinity of Region D are currently out of attainment for $NO_2$, $PM_{2.5}$, or $O_3$; 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.

EPA *de minimis* standards are not relevant. However, increased concentrations of these pollutants may pose a risk to air quality and contribute to regional haze and PSD increment consumption. MO3 would result in adverse effects to air quality near tribal lands due to dam breaching and an increased reliance on coal or natural gas. This would be less if the output of the Snake River dams was replaced with renewable energy.

In addition, any additional fossil fuel generation would have to follow the applicable emissions permitting and regulations, including evaluating and addressing potential effects on Class I areas. Chapter G-4 of Appendix G describes Class I areas in further detail, as well as providing a map of Class I areas in the Pacific Northwest.

The increased air pollutant emissions from coal would occur around the coal plants in Montana and Wyoming, which are adjacent to nonattainment areas for PM and $O_3$, respectively. Coal power generation generates $O_3$ precursors and can also create secondary PM emissions, and $SO_2$ and $NO_x$ can generate secondary PM when reacting in the atmosphere (Oak Ridge National Laboratory 2017). The additional emissions from coal generation in these areas may exceed *de minimis* levels of PM or $O_3$ precursor emissions (100 tons per year) for nonattainment areas, and may adversely affect regional compliance with NAAQS. Section 3.8.1 provides additional discussion of *de minimis* levels and conformity regulations.

**Air Pollutant Emissions from Navigation and Transportation under Multiple Objective Alternative 3**

MO3 involves major changes to river navigation in the lower Snake River within the Columbia River Basin Region C due to the breaching of the four lower Snake River projects, which would limit barge-based freight transportation on the lower Snake River. As described in Section 3.10.3, expected maximum water depth in the river is reduced under MO3, making the lower Snake River inaccessible to navigation. The analysis identifies a shift in freight transport in Region C from relatively low emissions barge-based transport to higher emissions rail- and truck-based transport. Specifically, Section 3.10.3 identifies an increase in rail freight (measured in total ton-miles) of up to 86 percent and in truck freight of up to 19 percent; if a rail rate (rail cost) increase were to occur due to the increased demand on rail freight, additional freight shifts to trucks and may increase truck freight by up to 84 percent relative to No Action Alternative.[20]

These modal transportation changes would likely lead to an increase in air pollutant emissions, specifically HAPs, VOCs, CO, PM, and $NO_x$, from rail and truck transportation under MO3 relative to No Action Alternative. The changes in these emissions would be very small relative 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.

The adverse effects on air pollutant emissions are likely long term and focused within Region C. The area of increased emissions in the lower Snake River overlaps maintenance areas in Washington and Oregon. The Wallula, Washington, maintenance area for $PM_{10}$ is close to the lower Snake River. While nearby Union County in Oregon is also a maintenance area for $PM_{10}$, the modal changes towards truck-based transport under MO3 most likely affects Washington and not Oregon (Section 3.10, *Navigation and Transportation*). Given that PM emissions rates are low for all modes (from 0.05 to 0.005 grams per ton-mile), it is unlikely that there is the potential for increased emissions to cross *de minimis* thresholds for PM emissions (100 tons per year) for maintenance areas. Increased air pollutants from moving goods that would have been barged would impact air quality near tribal lands along the Columbia River and could have adverse effects to tribes near the Lower Snake River dams, such as the Confederated Tribes of the Umatilla Indian Reservation and Nez Perce Tribe.

Given the potential effects of vehicle emissions on haze, this analysis considered whether the increased transportation emissions would affect sensitive areas, such as the Columbia Gorge National Scenic Area, a protected natural scenic area that runs 83 miles along the Columbia River, covering six counties in southern Washington and northern Oregon. The National Scenic Area Act of 1986 requires the protection and improvement of resources of the Gorge. The concern for air pollutants and emissions in this area are haze pollution and visibility issues given the recreational and scenic value of the area, as well as the potential for HAPs given the mixed use (e.g., forest, urban) of the scenic area.

Previous air quality studies of the Gorge Area identified on-road vehicles as one of many causes for regional haze (ODEQ 2011). Under MO3 modal transportation changes would occur, potentially diverting some barge freight onto additional trains or trucks. However, this analysis finds that these effects would be unlikely to occur in the near vicinity of the Gorge, but rather focused around the lower Snake River. Given this, it is unlikely that the increased truck transportation activity under MO3 would affect haze within the National Scenic Area. Chapter G-4 of Appendix G describes Class I areas in further detail as well as providing a map of Class I areas in the Pacific Northwest.

**Air Pollutant Emissions from Construction Activities under Multiple Objective Alternative 3**

The breaching of the four lower Snake River dams would involve construction activities, such as bulldozing and hauling to remove the embankments and certain structures surrounding the dams. These activities generate PM and other air pollutants from the operations of vehicles and equipment and there would be the potential for the suspension of dust from these activities by wind to affect neighboring areas.

In addition to dam breaching, MO3 includes upgrades to spillway weirs at McNary and John Day Dams. As with two of the other alternatives, the construction of new power-generating infrastructure to replace the reduction in hydropower generation would contribute to construction-related air pollutant emissions in the short term. The location of potential new resources is uncertain.

The timing of the projects would determine the magnitude of effects in the lower Snake River region. As presented in the description of alternatives, currently dam breaching would be in two phases starting with Lower Granite and Little Goose Dams, then Lower Monumental and Ice Harbor Dams. Given this focused construction activity on the lower Snake River in Region C, there is the potential for adverse effects on two maintenance areas for PM. Closest to the lower Snake River is the Wallula area in Washington and south, in Oregon, is the Union County maintenance area. Whether the additional PM emissions would exceed *de minimis* levels in these areas is uncertain. However, the effects would be short term and employing BMPs (as previously described) for these construction sites could mitigate potential adverse effects from construction activities. These construction-related effects could have short-term, adverse effects to tribes near the Lower Snake River dams, such as the Confederated Tribes of the Umatilla Indian Reservation and Nez Perce Tribe.

**Other Air Pollutant Emissions Sources under Multiple Objective Alternative 3**

Dam breach in MO3 would affect the conditions of the Snake River, including the width and elevation, as well as effects on two other CRS projects. The changes in elevation along the Snake River would be nearly 100 feet in certain areas and times of year. Changes in width would be the largest close to the dam breach sites, reducing width by up to 3,000 feet at Ice Harbor and Little Goose Dams.

These changes would result in exposed riverbed that is no longer submerged under the reservoirs, and increased potential for erosion and suspension of dust by wind, generating PM emissions. These changes would occur over time following the breaching of the various projects. The resulting potential for fugitive dust depends on a variety of factors including precipitation, wind, and temperature. Wind speeds at the Walla Walla and Tri Cities monitoring stations average roughly 8 miles per hour with few instances above high-wind event thresholds (i.e., 90 percent of recorded days were below 20 miles per hour). Appendix G provides more information on wind speeds and frequencies.

Over time, the risk of fugitive dust likely declines as vegetation covers the exposed sediment, reducing the potentially erodible area. Additionally, potential effects may be mitigated by planting of vegetation, restrictions on activities on the sediment such as recreation and use of vehicles, or by use of wind barriers for recreation areas.

Human populations exposed to “dust bowls” are at higher risk of adverse health effects from dust. Areas that have historically experienced dust bowl exposures include Spokane, Pullman, and Colfax in eastern Washington. In addition, the Wallula maintenance area for $PM_{10}$ is located at the confluence of the Columbia and Snake Rivers. The most recent exceedance events in the Wallula maintenance area all exceeded speeds of 29 miles per hour, which is well above recorded average wind speeds. However, without mitigation, there is the potential for windblown dust from the banks of the Snake River to increase PM emissions near this maintenance area in Region C, risking its ability to meet the NAAQS for PM.

## GREENHOUSE GAS EMISSIONS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 3

MO3 would have a larger effect on GHG emissions relative to the No Action Alternative, MO1, and MO2. While the dam breaching included in this alternative would affect GHG emissions due to shifts in river-based navigation and construction activities, the dominant effect is the increased GHG emissions from power generation as compared with No Action Alternative.

### Greenhouse Gas Emissions from Power Generation under Multiple Objective Alternative 3

$CO_2$ emissions in the Pacific Northwest from power generation under the MO3 conventional least-cost resource replacement portfolio would be 39.9 MMT $CO_2$ in 2022, approximately a 9 percent increase as compared with No Action Alternative in that year. Assuming the zero-carbon resource replacement, estimated emissions would be 37.7 MMT $CO_2$ in 2022 across the Pacific Northwest a 2.7 percent increase relative to the No Action Alternative. Given that policy and legislative decisions in Oregon and Washington are targeting large reductions in GHG emissions, a 2.7 percent increase in $CO_2$ emissions, even with the zero-carbon replacement resources, makes these goals more difficult to achieve.

Table 3-207 and Table 3-208 presents the total Pacific Northwest and Western Interconnection power generation-related emissions compared to No Action Alternative. Even under the zero-carbon resource replacement portfolio, MO3 would increase $CO_2$ emissions. This is because, even with considerable future construction of new renewables capacity, the level of reduction in hydropower generation means there are particular times seasonally or even daily (e.g., during peak demand) during which more flexible fossil fuel generation would be dispatched to meet demand over the timeframe of the analysis. In addition, the near-term effect of the reduction in hydropower, should the new replacement resources not be built by 2022 as assumed, would likely be a larger increase in power generation and emissions from existing fossil-fuel power plants to meet demand.

**Table 3-207. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple 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 |

Note: Pacific Northwest estimates include Jim Bridger and half of the remaining North Valmy coal power plant emissions. See footnote 16 for further description of these power plants. The conventional least-cost resource replacement portfolio relies primarily on natural gas generation to replace the reduction in hydropower, whereas the zero-carbon resource replacement portfolio relies primarily on generation from solar resources.
Source: AURORA outputs and NW Council (2019)

As described in Section 3.8.3.2, the power analysis is sensitive to alternative assumptions regarding coal capacity in the region. Under a limited or no coal future, the emissions effects under MO3 would depend on the nature of replacement resources (fossil fuel and renewable resources). If the reduction in coal were replaced by zero-carbon resources, emissions could decrease substantially; however, the amount of zero-carbon resources required would be very large, and even more substantial with the added effect of the reduction in hydropower under MO3, as presented in Table 3-208.

**Table 3-208. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple 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%)* |

Across the wider Western Interconnection, excluding regions outside of the United States, average emissions from AURORA in MO3 with the conventional least-cost replacement portfolio would be 166 MMT $CO_2$, approximately 2 percent greater than No Action Alternative. Under the zero-carbon resource replacement portfolio, average emissions would be 165 MMT $CO_2$, 1.3 percent greater than No Action Alternative. The more modest changes in emissions across the broader Western Interconnection area indicate that the effects of the alternative are focused in the Pacific Northwest under MO3.

**Greenhouse Gas Emissions from Navigation and Transportation under Multiple Objective Alternative 3**

Due to the dam breach under MO3, barge-based freight transportation of wheat on the lower Snake River would become inoperable and total barge transport (from farms in Region C to Portland in Region D) of wheat would fall by 64 percent (as discussed in Section 3.10, *Navigation and Transportation*). As a result of the loss of barge transport, truck- and rail-based freight transportation increase. As truck and rail transportation are associated with higher emissions per ton-mile than barges, this results in a net increase in $CO_2$ emissions in 2022 of approximately 17 percent as compared with No Action Alternative.

If, in addition to dam breaching, rail rates increase (as discussed in Section 3.10.3), freight transportation modes may shift away from rail. Under MO3 with a rail rate increase, $CO_2$ emissions may be up to 53 percent higher than No Action Alternative due to increased levels of 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.

difference from No Action Alternative. The increased $CO_2$ emissions from navigation and transportation under MO3 are modest as compared with the increased $CO_2$ emissions from power generation.

**Table 3-209. Navigation $CO_2$ Emissions by Type under Multiple Objective Alternative 3 and No Action Alternative in 2022 (MMT $CO_2$)**

| 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 |

Note: The emissions presented here are only $CO_2$, not equivalents, and are for the year 2022. The emissions estimates derive from changes in modal freight transportation analyzed in Section 3.10 and from emissions factors, by mode, presented in the Affected Environment (Section 3.8.2) from Kruse, Warner, and Olson (2017).

### Greenhouse Gas Emissions from Construction Activities under Multiple Objective Alternative 3

The construction vehicles and equipment used in dam-breaching activities along the lower Snake under MO3 would generate GHG emissions from the burning of fuel. In addition, construction of replacement resources to offset the reduction in hydropower generation under MO3 would result in short-term GHG emissions effects. These effects are short term, occurring during the construction period, and very modest as compared with the power generation-related GHG emissions under MO3.

### Other Greenhouse Gas Sources under Multiple Objective Alternative 3

MO3 would change the landscape around the lower Snake, exposing considerable shoreline area. To the extent that these areas are vegetated (either for mitigation or over time via natural succession), there may be increased levels of landscape carbon sequestration storage in the biomass and soil. However, this benefit of removing carbon from the atmosphere would be very modest relative to the increased carbon emissions from power generation under MO3.

### Meeting Emissions Reductions Targets under Multiple Objective Alternative 3

Under MO3, assuming the zero-carbon portfolio, $CO_2$ emissions would increase relative to No Action Alternative. The emissions increases would occur in Montana due to increased coal generation, which would affect regions with consumption-based targets that rely on Montana coal generation. While this coal generation may still be sold in some areas, after 2025 no coal related power costs can be included in retail customer rates in Washington State, and penalties apply after 2030 due to the Washington Clean Energy Transformation Act. Similarly, after 2030, no coal power costs can be included in retail customer rates in Oregon due to the Oregon Clean Electricity and Coal Transition Act (2016).

**Social Cost of Carbon Effects under Multiple Objective Alternative 3**

MO3 would increase GHG emissions relative to No Action Alternative. This analysis evaluates implications on emissions according to both the conventional least-cost and zero-carbon replacement portfolios. As previously described, recent and emerging policy focused on reducing energy sector GHG emissions indicates that the zero-carbon resource replacement portfolio may better reflect future trends. Appendix G includes the calculation of the emissions and SCC values by year over the timeframe of the analysis.

The central estimate for the present value of the increased climate-related damages under MO3 is $1.0 billion (assuming a 3 percent discount rate in accordance with best practices) (IWG 2016) and assuming the additional zero-carbon generation is constructed to replace lost hydropower generation. This equates to an annualized cost of $68 million relative to No Action Alternative. These costs reflect the global increase in climate-related damages associated with the expected marginal increase in GHG emissions under MO3. These values reflect a 3.0 percent increase in GHG emissions relative to the No Action Alternative over the 20-year timeframe.

Table 3-210 presents a range of results reflecting alternative assumptions regarding the appropriate discount rate for discounting these types of intergenerational effects, as well as a portfolio that reflects greater than expected (95th percentile) damages from climate change over time. Due to the considerable uncertainty inherent in the calculation of the SCC values, the results of the analysis according to these alternative assumptions are presented for consideration.

**Table 3-210. Present Value and Annualized Values of Changes in $CO_2$ Emissions in the Pacific Northwest under Multiple Objective Alternative 3 Relative to No Action Alternative (2022 to 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% 95th |
| 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 |

Notes: These estimates reflect three different discount rates (the averages used by three different climate models) and a high estimate of the 95th percentile for potential lower-probability, high-impact outcomes to capture uncertainty. The central estimate is the 3 percent discount rate. All values in this table rounded to two significant digits. Full values for each portfolio as well as the schedule for each discount rate SCC estimates are in Appendix G. Annualized values are calculated by first estimating the total present value of the future stream of costs, and then calculating the annualized estimates (i.e., average annual equivalent) employing the same discount rate assumption.
Source: IWG (2016); for SCC cost schedule over time, see Appendix G for full schedule

**SUMMARY OF EFFECTS**

Long-term adverse effects related to reductions in hydropower generation would lead to increased fossil fuel generation and associated emissions. Increased natural gas generation would be likely to increase emissions of $NO_x$ in Region D in Oregon, and coal generation in Wyoming and Montana, would increase emissions of $SO_2$, $NO_x$, PM, HAPs, and VOCs. The coal plants are near existing nonattainment areas for PM and $O_3$ and the additional emissions from coal have the potential to exceed *de minimis* levels of PM emissions, potentially affecting compliance with NAAQS. Exposed riverbed along the Snake River would increase potential for fugitive dust emissions in Region C. The associated PM emissions would occur adjacent to an existing maintenance area for PM (Wallula), risking the ability of this area to maintain adherence to NAAQS for PM. Overall, the effects of MO3 on air quality would most likely be moderate and adverse over the short and long term, primarily in Regions C and D and outside of the Pacific Northwest in areas of Montana and Wyoming.

Over the 20-year timeframe, the analysis identifies increased power generation from fossil fuels, including both coal and natural gas, even under the zero-carbon resource replacement portfolio. Long-term adverse effects on GHG emissions would also be associated with modal shifts in freight transport along the lower Snake River from barge to relatively high emissions rail and truck. The increased emissions would be minor relative to the power generation-related emissions. Construction activities, including dam breaching and construction of replacement power resources, would generate emissions. These are likely short term (during the period of construction). Overall, effects of MO3 on GHG emissions would be minor and adverse over the short term, and moderate and adverse over the long term.

### *3.8.3.6 Multiple Objective Alternative 4*

MO4 includes various structural and operational measures that would affect flow levels along the Columbia and Snake Rivers. Structural measures, such as modifications for spillways and other upgrades at the CRS projects, would require construction that creates GHG emissions and air pollutants. Various operational changes to spill, and changes to flow measures, would also affect hydropower generation. These measures in MO4 would reduce hydropower generation and affect navigation.

Under MO4, effects to air quality are anticipated to be similar in the Canadian portions as those described for the United States. However, the effects would reduce as the geographic distance from the CRS projects increase.

**AIR POLLUTANTS AND AIR QUALITY EFFECTS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 4**

Under MO4, air pollutant emissions would increase from the power generation, construction activities, and exposed reservoir sediment under MO4. The air quality effects from construction and exposed sediments would most likely be localized to the project site and short term (occurring during the construction period).

**Air Pollutant Emissions from Power Generation under Multiple Objective Alternative 4**

Under MO4, hydropower generation would decrease by 10 percent relative to No Action Alternative, resulting in the need for replacement generation to meet the demand for power. For both the conventional least-cost and zero-carbon portfolios, fossil fuel generation would increase. For the conventional least-cost portfolio, natural gas generation would increase by 15 percent and coal generation by 11 percent. These increases would lead to additional $SO_2$ and $NO_x$ emissions and HAPs and VOC emissions, as well as PM increases from the coal generation. For the zero-carbon replacement portfolio, natural gas would decrease by 2 percent relative to No Action Alternative, but coal power increases 6 percent, increasing overall air pollutant emissions. This increase in air pollutant emissions is due to the fact that fossil fuel generation increases when solar power generation cannot meet demand. MO4 would result in adverse effects to air quality near tribal lands due to an increased reliance on coal or natural gas. This effect would be less if the change in hydropower generation was replaced with renewable energy.

Any additional fossil fuel generation would be subject to and controlled by the applicable emissions permitting and regulation as described in Section 3.8.1. There is still the potential for changes to affect regional haze and deterioration of air quality even if new emissions do not violate these standards. Chapter G-4 of Appendix G describes regional haze in further detail.

The increase in coal power generation would result in air pollutant emissions around coal power plants in Montana. Coal power generation can also create PM emissions and $SO_{2,}$ and $NO_x$ can generate secondary PM when decomposing in the atmosphere (Oak Ridge National Laboratory 2017). In Montana, coal power plant locations are in proximity to nonattainment areas for PM and the additional emissions may exceed EPA *de minimis* levels. The increase in natural gas generation would result in increased emissions in Region D in Oregon; however, under the zero-carbon resource replacement portfolio, these increases would be negligible.

**Air Pollutant Emissions from Navigation and Transportation under Multiple Objective Alternative 4**

MO4 would slightly increase costs for deep draft navigation traffic below Portland, Oregon (in Region D), and slightly decrease costs for shallow draft traffic from Portland to McNary Dam, as well as on the Snake River (Regions C and D). As described in Section 3.10.3, the increased costs for deep draft traffic may result in "light loading" vessels, requiring more trips to transport the same amount of freight, and a small increase in the number of tug operations. Conversely, shallow draft traffic in Regions C and D would experience very slight reduction in costs (0.1 percent) in comparison to No Action Alternative.

The slight increase in shipping activity (i.e., barge trips) may result in a slight increase in emissions under MO4 relative to No Action Alternative in the long term. This analysis expects this would be low intensity and occurring within Regions C and D.

**Air Pollutant Emissions from Construction Activities under Multiple Objective Alternative 4**

Multiple structural measures under MO4 involve construction activities across the CRS projects, including additional fish passage routes, installing pumps and pipes, and upgrading turbines. The construction of additional powerhouse surface passage routes would occur at six projects: McNary, Little Goose, Lower Monumental, Bonneville, The Dalles, and Ice Harbor. The other structural measures involve primarily updating or modifying existing structures at projects including fish ladders and spillway weir notch inserts. The magnitude of these construction activities varies but all would require machinery and equipment, as well as vehicle travel to the site, which would increase air pollutants, especially PM, relative to No Action Alternative. In addition to construction for these powerhouse structural changes, construction of replacement power resources also emits localized air pollutants, though the location of these resources is uncertain.[22]

The CRS projects involved in the MO4 structural measures occur within Regions C and D. Activities at McNary and Ice Harbor Dams are close to the Wallula maintenance area for $PM_{10}$. However, as with the previously mentioned alternatives, air pollutant effects from construction would be localized and short term, and may be mitigated with application of BMPs.

**Other Air Pollutant Emissions Sources under Multiple Objective Alternative 4**

Under MO4, water surface elevation at multiple CRS projects would decrease compared to No Action Alternative, exposing additional shoreline. The River Mechanics analysis (Section 3.3.3.5) determined that the effects of these elevation changes were negligible apart from Hungry Horse Dam in Region A. Reservoir elevation levels at Hungry Horse experience a 2-feet reduction in all months except June and July relative to No Action Alternative.

Under high temperature and wind, and low precipitation conditions, the exposed sediment may increase fugitive windblown dust and associated PM emissions. Generally, the wind speeds at the nearest monitoring station in Kalispell are low with average speeds of 5 miles per hour and very rare occurrences of high-wind speed events (0.5 percent of recorded hourly data). Appendix G provides more information on wind speeds and frequencies. The potential for increased dust at Hungry Horse may occur seasonally over the long term and may be mitigated by planting vegetation or restrictions on activities on the sediment, such as recreation and use of vehicles. The effects would be local to the project site, which is located within a county that includes nonattainment areas for PM at Columbia Falls and Whitefish, Montana, (EPA 2019). Given the seasonal variation in water levels and potential for mitigation, such as vegetation planting, to avoid adverse effects, the likelihood that fugitive dust emissions would affect the 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.

### GREENHOUSE GAS EMISSIONS UNDER MULTIPLE OBJECTIVE ALTERNATIVE 4

The effects of MO4 on GHG emissions would be similar to MO3. Both alternatives would result in a considerable reduction in hydropower generation which would be, to some extent, replaced by fossil fuel generation that results in increased $CO_2$ emissions even under the zero-carbon resource replacement portfolio. This is the dominant effect of MO4 on GHG emissions under this alternative.

#### Greenhouse Gas Emissions from Power Generation under Multiple Objective Alternative 4

Power generation-related GHG emissions in the Pacific Northwest under MO4, assuming conventional least-cost resource replacement, would be 39.8 MMT $CO_2$ in 2022, 8.4 percent greater than No Action Alternative for that year. Assuming the zero-carbon resource replacement portfolio, emissions would be 37.0 MMT $CO_2$ in 2022, 0.8 percent greater than No Action Alternative. For similar reasons as described for MO3, some level of fossil fuel-based generation is likely to offset the reduction in hydropower generation. Table 3-211 presents the total power emissions for MO4 compared to No Action Alternative. Given that policy and legislative decisions in Oregon and Washington are targeting large reductions in GHG emissions, a 2 percent increase in emissions, even with the zero-carbon replacement resources, makes these goals more difficult to achieve.

Table 3-212 identifies the changes in emission under MO4 relative to No Action Alternative over the 20-year timeframe. The emissions effect of MO4 as compared with No Action Alternative would be relatively consistent over time. As previously described, recent and emerging policy focused on reducing energy-sector GHG emissions indicates that the zero-carbon resource replacement portfolio may better reflect future trends. However, the near-term effect of the reduction in hydropower, should the new replacement resources not be built by 2022 as assumed, would likely be an increase in generation and emissions from existing fossil-fuel power plants.

**Table 3-211. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple 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 |

Notes: Pacific Northwest estimates include Jim Bridger and half of the remaining North Valmy coal power plant emissions. See footnote 16 for further description of these power plants. The conventional least-cost resource replacement portfolio relies primarily on natural gas generation to replace the reduction in hydropower, whereas the zero-carbon resource replacement portfolio relies primarily on generation from renewable resources.

Source: AURORA outputs

**Table 3-212. Pacific Northwest Power Generation Greenhouse Gas Emissions under Multiple 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%)* |

As described in Section 3.8.3.2, the power analysis is sensitive to alternative assumptions regarding coal capacity in the region. Under a limited or no coal portfolio, the emissions effects under MO4 would depend on the nature of replacement resources (fossil fuel and renewable resources). If the reduction in coal were replaced by zero-carbon resources, emissions could decrease substantially; however, the amount of zero-carbon resources would be very large, and even more substantial with the additional effect of the reduction in hydropower under MO4, as presented in Table 3-213.

Across the wider Western Interconnection, excluding regions outside of the United States, average emissions from power generation under MO4 assuming the conventional least-cost replacement portfolio would be 167 MMT $CO_2$ in 2022, 2.7 percent greater than No Action Alternative. Assuming the zero-carbon portfolio, average emissions would be 163 MMT $CO_2$, or half a percent greater than No Action Alternative in 2022. The more modest effect on emissions from power generation across the broader Western Interconnection indicates that the effect of MO4 on GHG emissions is concentrated in the Pacific Northwest.

**Greenhouse Gas Emissions from Navigation and Transportation under Multiple Objective Alternative 4**

MO4 would slightly increase costs for deep-draft navigation traffic below Portland, Oregon, and slightly decrease costs for shallow-draft traffic from Portland to McNary Dam, as well as on the Snake River. As described in Section 3.10.3, the increased costs for deep-draft traffic may result in “light loading” vessels, requiring more trips to transport the same amount of freight, and a small increase in the number of tug operations. Conversely, shallow-draft traffic would experience very slight reduction in costs (0.1 percent) in comparison to No Action Alternative.

The slight increase in shipping activity (i.e., barge trips) may result in a slight increase in GHG emissions under MO4 relative to No Action Alternative in the long term. This effect would likely be limited, and negligible as compared with the GHG emissions effects from power generation under the alternative.

**Greenhouse Gas Emissions from Construction Activities under Multiple Objective Alternative 4**

Construction operations under MO4 include turbine upgrades, spillway improvements, and many additions for fish passage at multiple CRS projects. These structural measures require construction equipment and vehicles that emit GHG when burning fuel. In addition, construction of replacement resources to offset the reduction in hydropower generation under MO4 would result in short-term GHG emissions effects. These effects would be short term, occurring during the construction period, and very modest as compared with the power generation-related GHG emissions under MO4.

**Other Greenhouse Gas Emissions Sources under Multiple Objective Alternative 4**

MO4 would not affect reservoir methane emissions. Additionally, MO4 would not result in changes in land use (e.g., conversion from inundated to vegetated landscapes) that would affect carbon sequestration potential of the landscape.

**Meeting Emissions Reductions Targets under Multiple Objective Alternative 4**

Under MO4, assuming the zero-carbon resource replacement portfolio, the increased GHG emissions in resources located in Oregon and Washington would be minimal, with none exceeding 0.1 MMT $CO_2$. However, this would require more zero-carbon resource acquisitions for MO4 than for the No Action Alternative to achieve the states' goals. The largest increases occur in Montana due to the coal generation, which would be able to be sold in some areas (other than Washington and Oregon).

**Social Cost of Carbon Effects under Multiple Objective Alternative 4**

MO4 results in an increase in GHG emissions relative to No Action Alternative. This analysis evaluates implications on emissions according to both the conventional least-cost and zero-carbon replacement portfolios. As previously described, recent and emerging policy focused on reducing energy-sector GHG emissions indicates that the zero-carbon resource replacement portfolio may better reflect future trends. Appendix G includes the calculation of the emissions and SCC values by year over the timeframe of the analysis.

The central estimate for the present value of the increased climate-related damages under MO4 is $310 million (assuming a 3 percent discount rate in accordance with best practices) (IWG 2016) and assuming the additional zero-carbon generation is constructed to replace lost hydropower generation. This equates to an annualized cost of $20 million. These costs reflect the global increase in climate-related damages associated with the expected marginal increase in GHG emissions under MO4. These values reflect a 1.0 percent increase in GHG emissions relative to the No Action Alternative over the 20-year timeframe.

Table 3-213 presents a range of results reflecting alternative assumptions regarding the appropriate discount rate for discounting these types of intergenerational effects, as well as a portfolio that reflects greater than expected (95th percentile) damages from climate change over time. Due to the considerable uncertainty inherent in the calculation of the SCC values, the results of the analysis according to these alternative assumptions are presented for consideration.

**Table 3-213. Present Value and Annualized Values of Changes in $CO_2$ Emissions in the Pacific Northwest under Multiple Objective 4 Relative to No Action Alternative (2022 to 2041, 2019 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% 95th |
| 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 |

Notes: These estimates reflect three different discount rates (the averages used by three different climate models) and a high estimate of the 95th percentile for potential lower-probability, high-impact outcomes to capture uncertainty. The central estimate is the 3 percent discount rate. All values in this table rounded to two significant digits. Full values for each portfolio as well as the schedule for each discount rate SCC estimates are in Appendix G. Annualized values are calculated by first estimating the total present value of the future stream of costs, and then calculating the annualized estimates (i.e., average annual equivalent) employing the same discount rate assumption.
Source: IWG (2016): for SCC cost schedule over time, see Appendix G for full schedule

## SUMMARY OF EFFECTS

Overall, long-term adverse effects would be related to reductions in hydropower generation, which would increase fossil fuel generation and associated emissions. Increased coal generation under MO4 in Wyoming and Montana would increase emissions of $SO_2$, $NO_x$, and PM. The coal plants are near existing nonattainment areas for PM, and the additional emissions from coal have the potential to exceed *de minimis* levels of PM emissions, potentially affecting compliance with NAAQS.

In Regions C and D, long-term adverse effects would also be associated with increased barge transport along the lower Snake River due to reduced efficiency of shipping (i.e., light loading the barges to avoid grounding). The increased emissions would likely be low intensity, however, and very minor relative to the power generation-related emissions. Short-term adverse effects are due to construction activities, including structural measures and construction of replacement power resources, which would generate emissions. These would likely be short term (during the period of construction) and localized to the project sites in Regions C and D.

In Region A, reduced reservoir elevation levels at Hungry Horse Dam may occur for ten months of the year. The exposed sediment may increase fugitive windblown dust and associated PM emissions. This effect is localized and may be mitigated by planting vegetation or restrictions on activities on the sediment such as recreation and use of vehicles. The emissions would be located adjacent to nonattainment areas for PM in Columbia Falls and Whitefish, Montana. Given the seasonal variation in water levels and potential for mitigation to avoid adverse effects, the likelihood that fugitive dust emissions would affect the current nonattainment areas is low.

Overall, the effects of MO4 on air quality would most likely be moderate and adverse over the long term, primarily outside of the Pacific Northwest in areas of Montana and Wyoming, and minor and adverse in the short term in Regions A, C, and D.

Over the 20-year timeframe, the analysis identifies increased power generation from fossil fuels relative to No Action Alternative, primarily from coal, even under the zero-carbon resource replacement portfolio. Long-term adverse effects are also associated with increased barge transport along the lower Snake River in Regions C and D due to reduced efficiency of shipping. The increased emissions would be very modest relative to the power generation-related emissions. MO4 would also result in short-term adverse effects on GHG emissions from construction activities, including structural measures and construction of replacement power resources. Overall, effects of MO4 on GHG emissions would be moderate and adverse over the short and long term for similar reasons to MO3.

### 3.8.4 Tribal Interests

There are numerous tribal lands within the study area where air quality is potentially affected by operations. Because of the nature of airsheds, the power grid, and where additional power plants may be constructed, air quality near tribal lands would be affected, either beneficially or negatively, across the entire study area. Construction-related emissions, such as building additional powerhouse surface passages, improved turbines, or lamprey passage structures, would have short-term, localized effects to nearby communities. Depending on the alternative, there would be adverse effects to air quality in Regions A, C, and D, and also in Montana and Wyoming due to construction, changes in hydropower generation, and increased coal and natural gas power generation.

MO2 would have the least negative effects to air quality near tribal lands because there would be more hydropower generation than under the No Action Alternative, barging would continue on the lower Snake River the same as the No Action Alternative, and there would be no construction related to replacement power resources as there are under MO1, MO3, and MO4. The exception for MO2 is at Dworshak where there would be minor effects from potential increased fugitive dust emissions due to reduced reservoir water levels. This would most likely impact the Nez Perce Tribe as it overlaps spatially with the Nez Perce Reservation.

MO3 would result in adverse effects to air quality near tribal lands due to dam breaching and the potential for increased reliance on coal or natural gas. This would be less if the output of the Snake River dams was replaced with renewable energy. There would also be more construction-related effects that would have short-term, adverse effects to tribes near the Lower Snake River dams, such as the Umatilla Tribe and Nez Perce Tribe. Increased greenhouse gas emissions from moving goods that would have been barged would impact air quality near tribal lands along the Columbia River.

MO4 would have similar, albeit lower, effects compared to MO3 due to the changes in spill that affect hydropower generation and navigation.

## 3.9 FLOOD RISK MANAGEMENT

Flood Risk Management (FRM) is the process of identifying, evaluating, selecting, implementing, and monitoring actions intended to reduce the risk associated with flooding. The FRM analysis describes estimated effects of the MOs on FRM in the CRSO study area (defined in Section 3.9.2, *Area of Analysis*). Specifically, the MOs may affect the reservoir operations and/or system configuration (breaching of lower Snake River projects). The purpose of the CRSO FRM analysis is to assess whether changes in reservoir operations and system configuration would change flood risk when compared to the No Action Alternatives. Therefore, the focus of this analysis is to assess flood risk management, and to identify the communities, property, and resources downstream of reservoirs and in reservoir pools that could face increased frequency or magnitude of flooding under any of the identified MOs. To accomplish this, the FRM analysis examines potential changes in river flow and stage conditions in various locations throughout the system. River flow and stage information is compared to thresholds for flood hazards, as established by the National Weather Service (NWS) to understand flood risk conditions under the No Action Alternative, as well as how the conditions associated with the potential for flood hazards could change under the MOs.

### 3.9.1 Introduction and Background

Throughout history, numerous floods have occurred throughout the Columbia River Basin with consequences that have ranged from nuisance flooding, to catastrophic. Since the enactment of the Flood Control Act of 1917, the Corps has played a significant Federal role in managing flood risk nationwide. The mission of the Corps and how that mission has been implemented has evolved over time; moving from flood control to FRM. The transition to the current terminology reflects the natural variability in flood risk, the uncertainty of performance of infrastructure like levees and dams, and the uncertainty of which resources are vulnerable to flooding. Over the last 100 years, many FRM projects have been implemented in the Columbia River Basin, including several Federal projects. Although flood risk has decreased with these projects in place, no project can eliminate risk; residual risks remain even after projects have been implemented.

The role of the Federal government in managing flood risk in the Columbia River Basin began in 1925, when Congress requested that the Corps provide a cost estimate for preparing a detailed survey of the nation's navigable rivers for the development of navigation, hydropower, irrigation, and flood control. The Corps produced a comprehensive proposal that included the Columbia River Basin. That proposal was later adopted in U.S. Congress House Document (H. Doc.) 69-308 (1926)[1] and additional studies were authorized. The series of subsequent reports is known as the House Document 308 reports and present the preliminary concepts for the development of the Columbia River Basin.[2]

During the 1930s, a series of disastrous nationwide floods and the financial depression led to 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

flood control provided by the Federal government in cooperation with local entities, and provided funding specifically for flood control projects.[3] Many of the existing levees in the Columbia River Basin were constructed under this act.

Shortly afterwards in 1948, a major flood devastated communities along the Columbia River, in particular Vanport, Oregon, which was located adjacent to Portland, Oregon. Vanport was a "new town" created on the banks of the Columbia River primarily to build ships during World War II. Following the 1948 flood, political pressure and a directive from President Truman accelerated the completion of the Corps studies previously initiated by H. Doc. 308. The results of the studies were summarized in H. Doc. 81-531: "Columbia River and Tributaries, Northwestern United States," in March 1950. The report introduced a systemwide approach to FRM (generally referred to as flood control in this and earlier documents) and included a main control plan that proposed numerous new reservoirs and levee projects.

H. Doc. 531 served as the basis for the design of the present system. Over the next decade, however, the proposed control plan evolved, as many of the proposed projects were further evaluated and alternative projects were considered due to engineering, economic, political and public opinion concerns. Also in the 1960s, the United States and Canada began negotiations for implementing the Columbia River Treaty (CRT). The history of the system control plan can be tracked through the details of several CRT-specific studies and reports including the Special InterAgency Study: "U.S. and Canadian Storage Projects, Columbia River and Tributaries" (U.S. Department of the Interior 1955) and Report of the International Joint Commission, United States and Canada, Principles for Determining and Apportioning Benefits from Cooperative Use of Storage Waters and Electrical Inter-Connection within the Columbia River System (International Joint Commission 1959).

The CRT was signed in 1961 and later ratified on September 16, 1964. The CRT required Canada to provide 15.5 Maf of storage at three dam sites: Duncan, Arrow (later renamed Hugh Keenleyside), and Mica. Canada constructed 20.5 Maf of storage, including an extra 5 Maf of non-CRT storage at Mica Dam. The CRT provided 8.45 Maf of primary flood control space and the remaining space in Canada as secondary flood control space. The CRT also allowed the United States the option to build Libby Dam, which created a reservoir that extended across the U.S.-Canada border into Canada.

The FRM projects developed and implemented in the last century play an important role in the communities of the Columbia River Basin by reducing risk to lives, property, and the environment. Flood risk is also managed by systems of levees, floodwalls, and bank protection developed locally (either without Federal participation or constructed by the Corps in some cases with a cost-share local sponsor). In addition, many areas have adopted measures such as floodplain regulations, land use regulation, and improved land treatment practices, all of which are measures that manage flood risk.

[3] The 1936 act authorized construction of approximately 250 projects.

### 3.9.2 Area of Analysis

There are 14 CRS projects located within the U.S. portion of the Columbia River Basin, six of which are storage projects. A storage project is capable of drawing down its pool and refilling to store large amounts of water seasonally to regulate flows downstream for a variety of purposes, including FRM. The six CRS storage projects are described in Table 3-214. The table presents the volume of active storage (the portion of a reservoir that can be used for FRM and/or other purposes) and authorized system storage for FRM purposes.

**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** |

1/ Active storage is the portion of a reservoir that can be used for flood control and other purposes.
2/ Authorized System Storage for FRM is the storage volume specifically allocated for FRM.

The geographic scope of the FRM study area includes the CRS and all urban and rural areas and populations potentially affected by change to flood risk. The areas where an alternative could potentially affect flood risk are either downstream of one of the six storage projects, or upstream within the reservoir of the project. The study team delineated the study area into separate hydraulically distinct reaches to facilitate the analysis of flood risk. The details of this analysis are described in detail in Section 3.2, *Hydrology and Hydraulics.*

Flood gages have been installed in areas near population centers and where flood risk is a concern. This analysis evaluates a subset of the flood gages to characterize current flows and anticipated changes in flood risk under the MOs. Figure 3-192 provides an overview of the study regions, relevant projects, and gages that are the focus of the analysis.

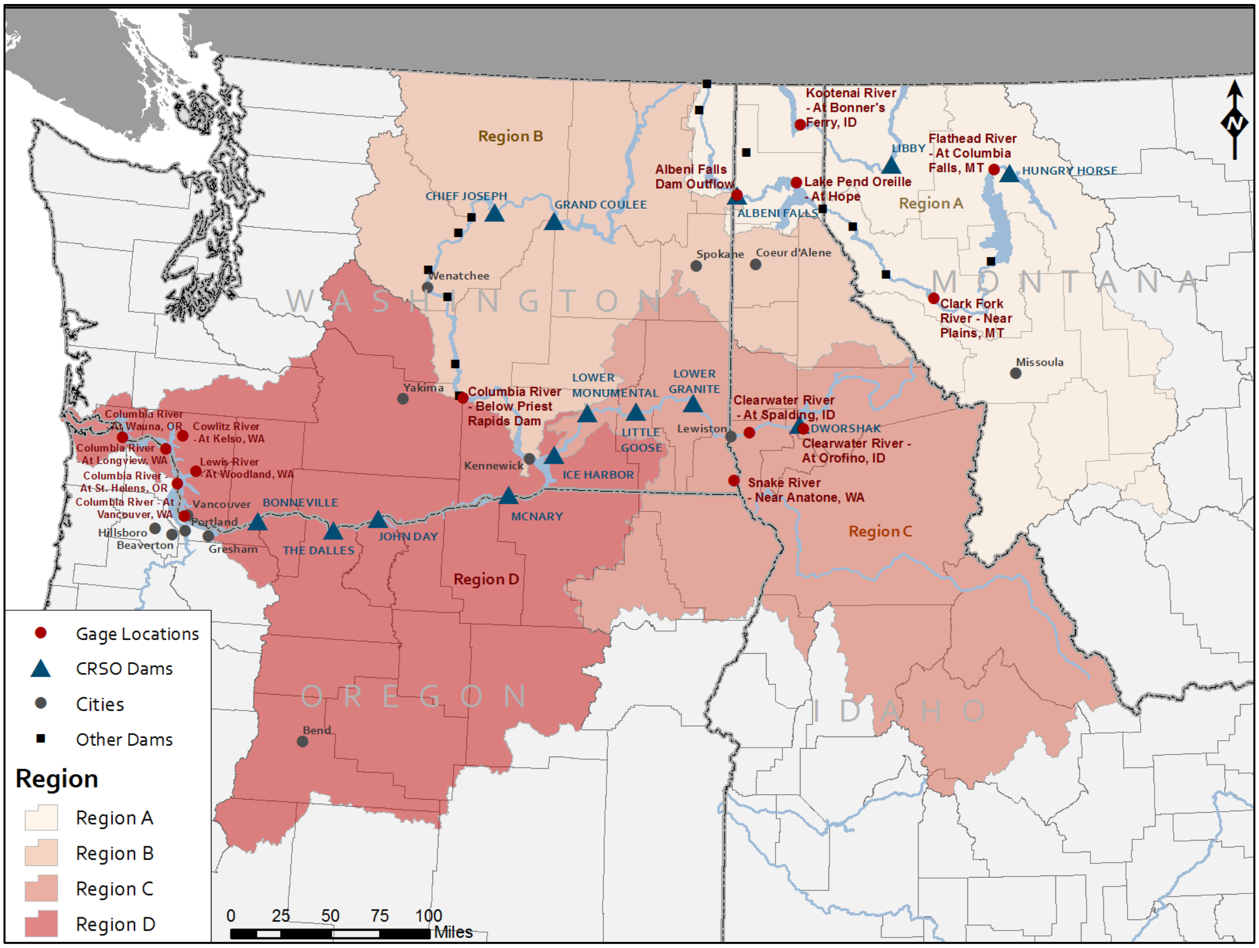


**Figure 3-192. Columbia River System Dams, Leveed Areas, and Important Gages for Flood Risk Management**

Note: The gages on the above map as well as historical stage/flow and flood hazard category threshold data used in this assessment are taken from The NWS Advanced Hydrologic Prediction Service at https://water.weather.gov/ahps/.

### 3.9.3 Affected Environment

The sections that follow describe flood risk by CRSO region, including the history of flooding within each region, and the location of levees that provide FRM to the identified communities.

Flood risk is an estimate of the risk of an area to flooding. Flood risk is a function of the hydrologic and hydraulic flood hazards that exist in a particular area (river flows and stages), the expected performance of levees and other infrastructure to reduce the probability of flooding, and finally, the consequences if flooding does reach communities or property (i.e., the harm that may be caused).

As a tool for measuring potential change to FRM conditions, flood hazard categories developed by the NWS are utilized for assessing flood hazards measured by the potential for inundation that involves risks to life, health, property, and natural floodplain resources and functions

(FEMA 2019). The NWS uses the following flood hazard categories, ranked by river stage (gage height):

- **Action Stage**: the stage which, when reached by a rising stream, represents the level where the NWS or a partner/user needs to take some type of mitigation action in preparation for possible significant hydrologic activity.
- **Flood Stage**: the stage above which a rise in water surface level begins to create a hazard to lives, property, or commerce. The issuance of flood advisories or warnings is linked to flood stage.
- **Moderate Flood Stage**: the stage above which a rise in water surface level begins to have some inundation of structures and roads near the stream. Some evacuations of people and/or transfer of property to higher elevations may be necessary. A Flood Warning should be issued if moderate flooding is expected during the event.
- **Major Flood Stage**: the stage above which a rise in water surface level begins to have extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations are necessary. A Flood Warning should be issued if major flooding is expected during the event.

The potential for flood hazards in the Columbia River Basin is typified by two important runoff patterns in the Columbia River Basin: the snowmelt runoff in the interior east of the Cascade Mountain Range, and the rainfall runoff from the coastal drainages west of the Cascades affecting the lower Columbia. Most of the annual precipitation in the Columbia River Basin occurs in the winter, with the largest share in the mountains falling as snow. The moisture that is stored during the winter in the snowpack is released in the spring and early summer. Stream flow typically begins to rise in mid-April, reaching a peak flow during May or early June. About 60 percent of the natural annual runoff in the Basin occurs during May, June, and July.

Flood risks are managed in the Columbia River Basin by a system of FRM storage reservoirs, which in total provide approximately 40 Maf of storage capacity. This is compared to an average annual runoff volume of 130 Maf in the basin, and a historic maximum runoff of 192 Maf. The ability of the system of reservoirs to manage flood risk is further limited by the ability to predict, or forecast, the volume of runoff through the year.

The Pacific Northwest has two principal flood seasons. November through March is the rain-produced flood period. These floods occur most frequently on streams west of the Cascade Range. May through July is the snowmelt flood period. Most of the annual precipitation in the Columbia River Basin occurs in the winter, with the largest share in the mountains falling as snow. The moisture that is stored during the winter in the snowpack is released in the spring and early summer. East of the Cascade Range, snowmelt floods dominate the runoff pattern for the Columbia River Basin. The most serious snowmelt floods develop when extended periods of warmer weather combine with a large accumulation of winter snow. The worst floods result when heavy rains fall during a heavy snowmelt.

The Columbia River has an average annual flow volume at its mouth of about 198 Maf and an average annual flow of 273,500 cfs. A location in the lower Columbia River Basin, at The Dalles, Oregon, is where system runoff flows are modeled and measured. At this location, the average annual flow volume is 134 Maf and the average annual flow is 185,000 cfs. Average, high, and low Columbia River unregulated stream flows from historical records at The Dalles are shown in Figure 3-193. Historic records show an annually recurring pattern, with peak flows in late spring.

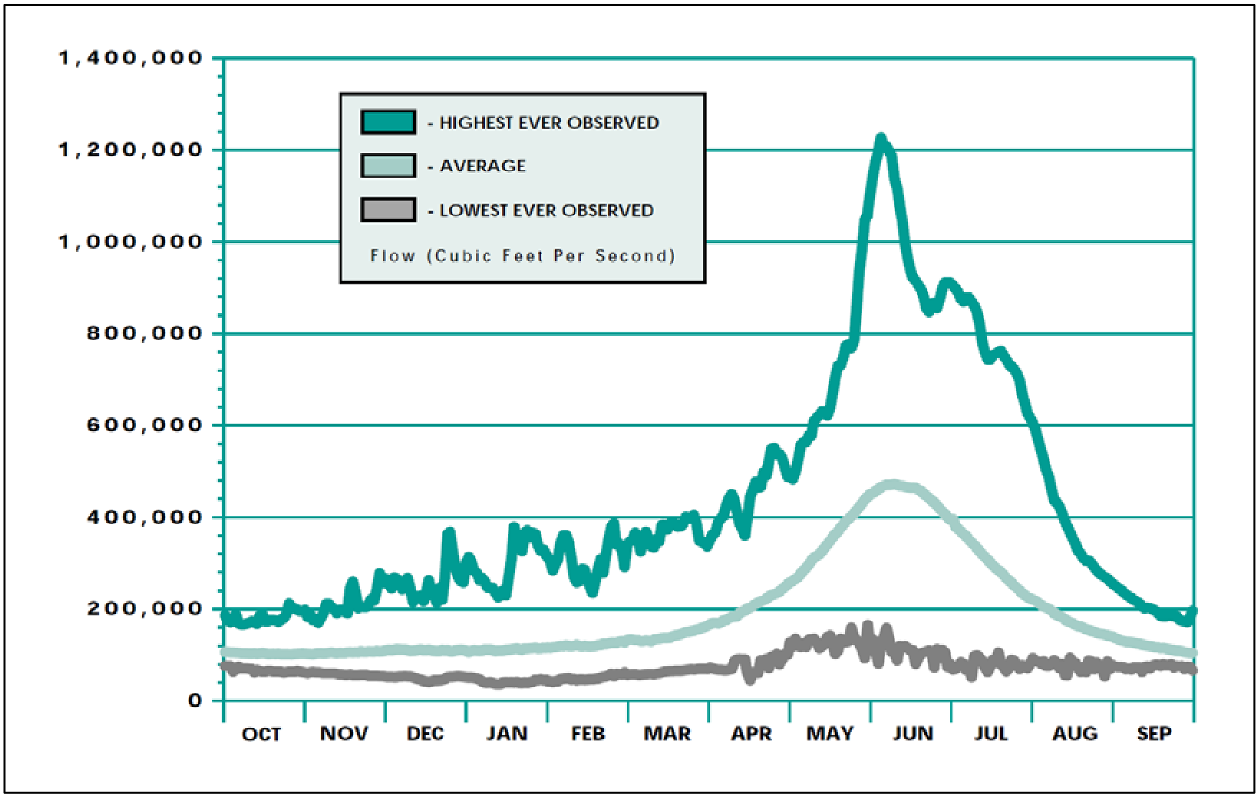


**Figure 3-193. Columbia River Streamflows as Measured at The Dalles, Oregon**

Seasonal flooding resulting from these snowmelt events was the primary driver for development of the FRM system on the Columbia River.

U.S. and Canadian water management agencies use seasonal runoff volume forecast information to formally plan the storage and release of water from the reservoirs. Corps, British Columbia Hydro, Reclamation, Natural Resource Conservation Service (NRCS) and the Northwest River Forecast Center produce seasonal runoff volume forecasts (rain and snowmelt) for numerous locations in the Basin, all of which are considered when determining the amount of space needed in the flood storage reservoirs. However, full knowledge of where and when flooding would occur still remains uncertain because it is not possible to accurately forecast the weather more than a few days ahead. The amount of rain and variations in temperature over just a few days, for example, can strongly influence the timing and extent of runoff. Unpredictable weather, along with climatic influences, can result in dramatic fluctuations in runoff volumes making FRM in the Columbia River Basin a major challenge.

No single agency or action can manage these floods. An entire system, with both manmade and natural features, contributes to flood reduction. Huge reservoirs can capture vast quantities of water, wetlands can absorb floodwaters and even the individual actions of property owners can help. The Corps, Bonneville, and other agencies also assist communities with non-structural measures that help manage floods, such as establishing response and land development plans to reduce flood risks.

FEMA defines special flood hazard areas as areas that will be inundated by a flood event that has a 1 percent chance of being equaled or exceeded in any given year (also called a 100-year flood). Areas of moderate flood hazard are identified as areas between the 0.1 percent and 0.2 percent annual chance of exceedance (between the 100-year flood and the 500-year flood mark) (FEMA 2019a). Communities that intersect the study area as well as populations that fall within these flood hazard areas are described in the following sections.

#### *3.9.3.1 Region A*

Region A includes the Libby, Hungry Horse, and Albeni Falls storage projects. The river reaches that are relevant to the FRM analysis in Region A are shown in Table 3-215 and are consistent with those used in the H&H resources analysis. Region A includes four gages that were selected for this analysis: Pend Oreille River Outflow from Below Albeni Falls; Clark Fork near Plains, Montana; Columbia Falls, Montana; and Bonners Ferry, Idaho. These gages are located on the Flathead River downstream of Hungry Horse Dam, and on the Kootenai River downstream of Libby Dam. Figure 3-194 presents the stream reaches, gages for which flood hazard categories have been defined by NWS, and large population centers that are relevant to FRM in Region A.

Most areas experienced flooding in the first half of the twentieth century, but flood frequency has been reduced in more recent years due to FRM efforts, including installation of levees in some areas. The most recent flood incident in this region was in Clark Fork, Idaho, which experienced flooding in 2018, although a non-Federal levee exists in that reach. The river communities that fall within Region A and the history of flooding in those communities is briefly summarized as follows:

- The Pend Oreille River in Reach 22 (R22) and R23 has historically flooded near Cusick and the Kalispel Reservation, near Newport Washington, and rural areas downstream to Metaline Falls. There was extensive damage in the 1948 flood. Flooding also occurred in 1933 and 1894. Flooding has not occurred recently in this area. R23 includes the Pend Oreille River Outflow from Below Albeni Falls gage.
- Flooding in R24 has historically occurred near Old Town and Priest River, Idaho on the Pend Oreille River, around areas of Lake Pend Oreille including Sandpoint, Idaho and low-lying regions of the lake, and on the Clark Fork River at Clark Fork Idaho. Floods have occurred in R24 in 1894, 1913, 1927, 1928, 1933, 1948, 1956, 1969, and 1974. The community of Clark Fork, Idaho experienced flooding in 2018. The Lightning Creek Levee is a non-Federal levee in R24 that provides FRM for the town of Clark Fork, Idaho.

- Flooding along the Clark-Fork and Flathead Rivers in R25, R26, and R27 has occurred in the past at Plains, Montana and in rural areas near Noxon, Paradise and Dixon, Montana. Approximately half of R27 is within the Flathead Reservation on the Flathead River. Major flooding in these areas occurred in 1894 and 1948. There are two non-Federal levees on the left bank of the Clark Fork River opposite Plains, Montana. R27 includes the Clark Fork near Plains, Montana, study gage.

- R28 has experienced flooding historically along the Flathead River at Columbia Falls downstream to Flathead Lake, and in areas around the lake. Part of R28 is within the Flathead Reservation in the lower portions of Flathead Lake. The flood of record in 1964 caused catastrophic flooding in the region. There are eight non-Federal levees systems in R28 along the Flathead River, providing FRM to portions of Evergreen, Bigfork and Kalispell, Montana and the surrounding communities. The stretch of R28 shown in the map below contains approximately 0.5 square miles of leveed areas, related to 3 non-Federal levees. R28 includes the Columbia Falls, Montana, study gage.

- The Kootenai River in R29 and R30 was subject to frequent and major flooding prior to the construction of Libby Dam, whose operation commenced in 1972. Historically, flooding occurred in the Kootenai Flats area, which encompasses all of R29, extending from Bonners Ferry, Idaho, to Kootenay Lake in Canada. Large areas of agricultural land, as well as the community of Bonners Ferry are subject to potential flooding. Much of the land is protected by non-Federal levees and dikes. R29 and R30 encompass lands belonging to the Kootenai Tribe of Idaho. During the 1948, flood all levees in R29 either failed or were overtopped, and about 44,000 acres of farm land were inundated in the Kootenai Flats area, 30,000 acres being in the United States.[4] Levees in R29 provide FRM to the City of Bonners Ferry, Idaho, and the Kootenai Flats agricultural region downstream. R29 includes the Bonners Ferry, Idaho, study gage.

The estimated population of communities in Region A is approximately 78,000, of which 10,000 reside in the flood hazard area.[5] Region A rural areas include an estimated population of approximately 35,000 people, of which 6,000 are located in the flood hazard area. Communities that intersect the study area as well as populations that fall within the flood hazard areas in Region A are listed in Table 3-216. The largest population in the study area is near Kalispell and Evergreen, Montana.
reservation trust lands in Region A, including the Kootenai Tribe of Idaho, the Confederated Salish and Kootenai Tribes, and the Kalispel Tribe of Indians.

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[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.

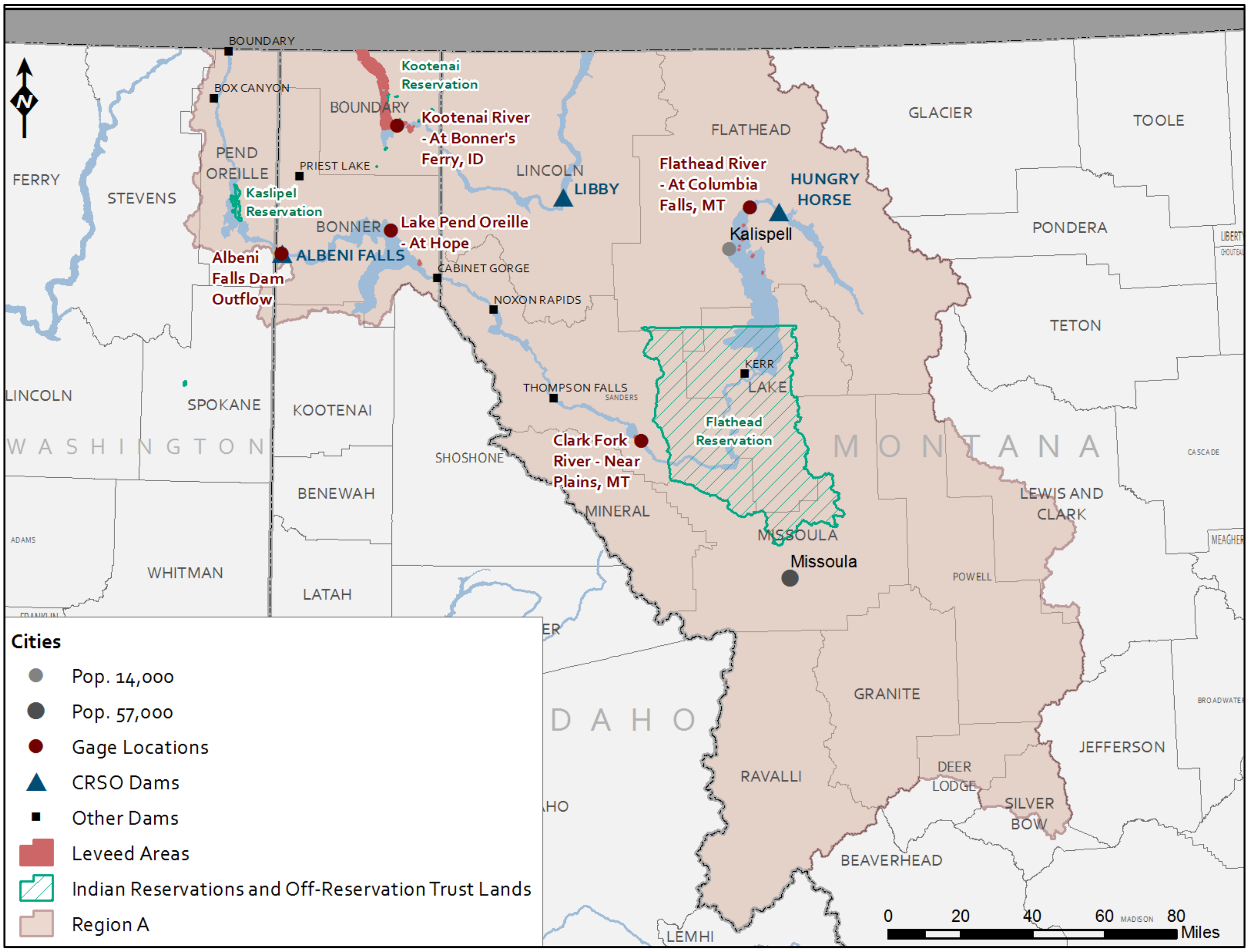


**Figure 3-194. Locations of Columbia River System Dams, Levees, and Other Dams in Region A**

**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) |

**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 |
| Bonners 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 |
| Ione, 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** | |

[1/] Source: U.S. Census Bureau (2017) or latest available data.

[2/] Source: ESRI data that is derived from U.S. Census data for unincorporated areas that are census-designated places.

[3/] Includes 1% and 0.2% annual chance exceedance flood hazard areas. 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.

#### *3.9.3.2 Region B*

Region B includes the Grand Coulee storage project. Another Federal dam, Chief Joseph Dam near Brewster, Washington, is also in this region, but it is not a storage project. The river reaches that are relevant to the FRM analysis in Region B are shown in Table 3-217, and are consistent with those used in the H&H resources analysis. The largest population center in the affected area is the town of Wenatchee, Washington (population 34,000), and its suburbs. Region B includes a gage called "Below Priest Rapids, Washington." This gage is located in Reach 14. Figure 3-195 presents the stream reaches, gages for which flood hazard categories have been defined by NWS, and large population centers that are relevant to FRM in Region B.

Most areas experienced flooding in the first half of the twentieth century, but flood frequency has been reduced in more recent years due to FRM efforts, including installation of levees in some areas. The river communities that fall within Region B and the history of flooding in those communities is briefly summarized as follows:

- R05 is combined with R14 and encompasses the McNary Dam reservoir (located in Region D) and the Below Priest Rapids gage (located in Region B), as well as the Tri-Cities area consisting of the majority of Richland, Kennewick, and Pasco, Washington, and surrounding suburbs. The boundary between Regions B and D runs through the Tri-Cities area. FRM is provided in these cities by federally constructed levees which are a part of the McNary Dam project completed in the early 1950s. There is little information available on historic flooding in this reach.
- The R15 and R16 reaches are sparsely populated. Historic flood information is not available for these reaches. Agricultural fields are adjacent to the Priest Rapids reservoir (Columbia River) in R15. The Crescent Bar recreational area is adjacent to Lake Wanapum (Columbia River) in R16 near Trinidad, Washington. The gage at Below Priest Rapids is located at the downstream end of R15.
- R17 includes the communities of Wenatchee and Rock Island, Washington. In R18 the communities of Enitiat and Chelan, Washington are adjacent to the Columbia. Historically, flooding has occurred on the Wenatchee, Entiat and Chelan tributaries in these reaches.

- The Methow and Okanogan Rivers flow into the Columbia in R19. Within this reach are the communities of Pateros, Brewster and Bridgeport, Washington. Within R20, the communities of Nespelem, Elmer City and Coulee Dam, Washington, are adjacent to Rufus Woods Lake (Columbia River behind Chief Joseph Dam). Historic flooding of the Methow and Okanogan Rivers in this reach has occurred.
- R21 contains the communities of Grand Coulee, Inchelium, Gifford, Kettle Falls, Marcus and Northport, Washington, as well as numerous other communities and recreational areas nearby. The Colville Reservation is adjacent to Lake Roosevelt across the entire right descending bank of this reach, and the Spokane Reservation is located on the left bank above the confluence of the Spokane River. Historically, flooding from tributaries such as the Colville River occurred in this reach.

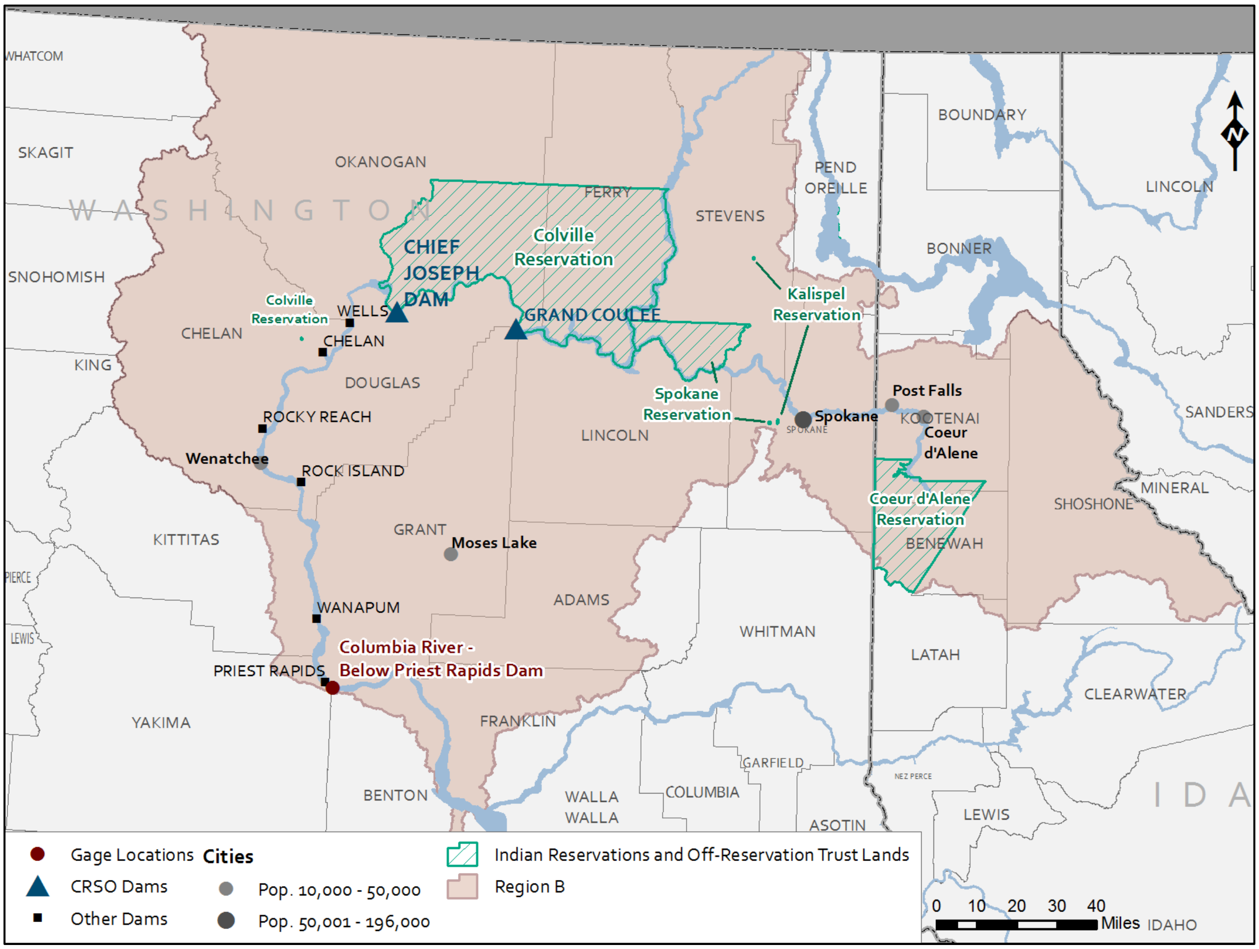


**Figure 3-195. Locations of Columbia River System Dams, Levees, and Other Dams in Region B**

**Table 3-217. River Reaches in Region B**

| Reach | Description |
|---|---|
| R05-R14/1 | Columbia River - McNary Dam to Ice Harbor and Priest Rapids (Columbia RM 291–397) and Snake RM 0–8[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) |

1/ R05-R14 intersects Regions B and Region D. McNary Dam is in Region D and Snake RM 08 is in Region D.

A major population center in this region is the Tri-Cities area that consists of Kennewick, Pasco, and Richland, Washington. The estimated population of communities in Region B is 284,937, of which 29,798 are in the FEMA flood hazard area.[6] Region B rural areas include an estimated population of 16,000 people, of which 7,000 are located in the FEMA flood hazard area. The largest population center in the affected area is the Kennewick, Washington (population 82,000), and its suburbs. Communities that intersect the study area as well as populations that fall within FEMA flood hazard areas in Region B are listed in Table 3-218. There are also a number of tribes with reservation lands and off-reservation trust lands in Region B, including the Confederated Tribes of the Colville Reservation (CTCR), the Spokane Tribe of Indians, and the Coeur d'Alene Tribe.

**Table 3-218. Communities within Region B 100- and 500-Year Floodplains**

| Community | 2017 Estimated Population 1/ | 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** | | |

1/ Source: U.S. Census Bureau (2017) or latest available data.
2/ Source: ESRI data that is derived from U.S. Census data for unincorporated areas that are census-designated places.
3/ Some portions of the Tri-Cities area are located in Region B and some in Region D. Reported populations are included in one region only (to avoid double counting).
4/ Includes 1% and 0.2% annual chance exceedance flood hazard areas. 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.

#### *3.9.3.3 Region C*

Region C includes much of the lower Snake portion of the Columbia Snake River system. Dworshak storage project is the only Federal project with storage in Region C. The river reaches that are relevant to the FRM analysis in Region C are shown in Table 3-219, and are consistent with those used in the H&H resources analysis. As noted above, this analysis uses flood gages along a subset of these reaches to characterize current flows and anticipated changes under the MOs. Region C includes three gages: Anatone, Washington; Orofino, Idaho; and Spalding, Idaho. Orofino Gage is on the mainstem of the Clearwater River a few miles above the confluence with the North Fork. The Spalding Gage is on the Clearwater downstream of Orofino and Dworshak. The Anatone gage is on the Snake River upstream of the Clearwater Confluence at Lewiston, Idaho. presents the stream reaches, gages for which flood hazard categories have been defined by NWS, and large population centers that are relevant to FRM in Region C.

The river communities that fall within Region C and the history of flooding in those communities is briefly summarized as follows:

- R06, R07 and R08 are sparsely populated reaches. There are grain terminals for marine loading, natural sites and recreational areas adjacent to the river. Historic flood information is not available for this area.
- R09 includes Clarkston, Washington and Lewiston, Idaho, at the confluence of the Snake and Clearwater Rivers. There are levees at Clarkson and Lewiston that are intended to contain the Snake and Clearwater Rivers (including flood flows) and prevent flooding within the cities. These levees were built as part of the Lower Granite Project, which does not have an FRM project purpose. The levees have been referred to informally as flow conveyance levees and were designed to prevent flooding within the cities when the Lower Granite pool

was filled in the 1970s. The area behind the levees contains highly developed industrial, commercial and residential property. R09 extends up the Snake River to Hells Canyon dam and up the Clearwater River to its confluence with the North Fork of the Clearwater (Dworshak Dam). From Lewiston to Dworshak Dam, the Clearwater has a long, narrow floodplain with roads and a railroad along the river and small areas of residential development, and includes the cities of Spalding and Orofino, Idaho, several unincorporated communities, and the Nez Perce Reservation along the entire stretch of the Clearwater. From Lewiston to Hells Canyon Dam the Snake River has a long, narrow floodplain that is includes the cities of Asotin, and Rogersberg, Washington. Flooding in R09 occurred in 1948 at Clarkston, Washington and Lewiston, Idaho, and along the Clearwater to Orofino, Idaho, and in the Grand Ronde tributary, which flows into the Snake near Rogersberg, Washington. All three indicator gages are located in this reach (Figure 3-196).

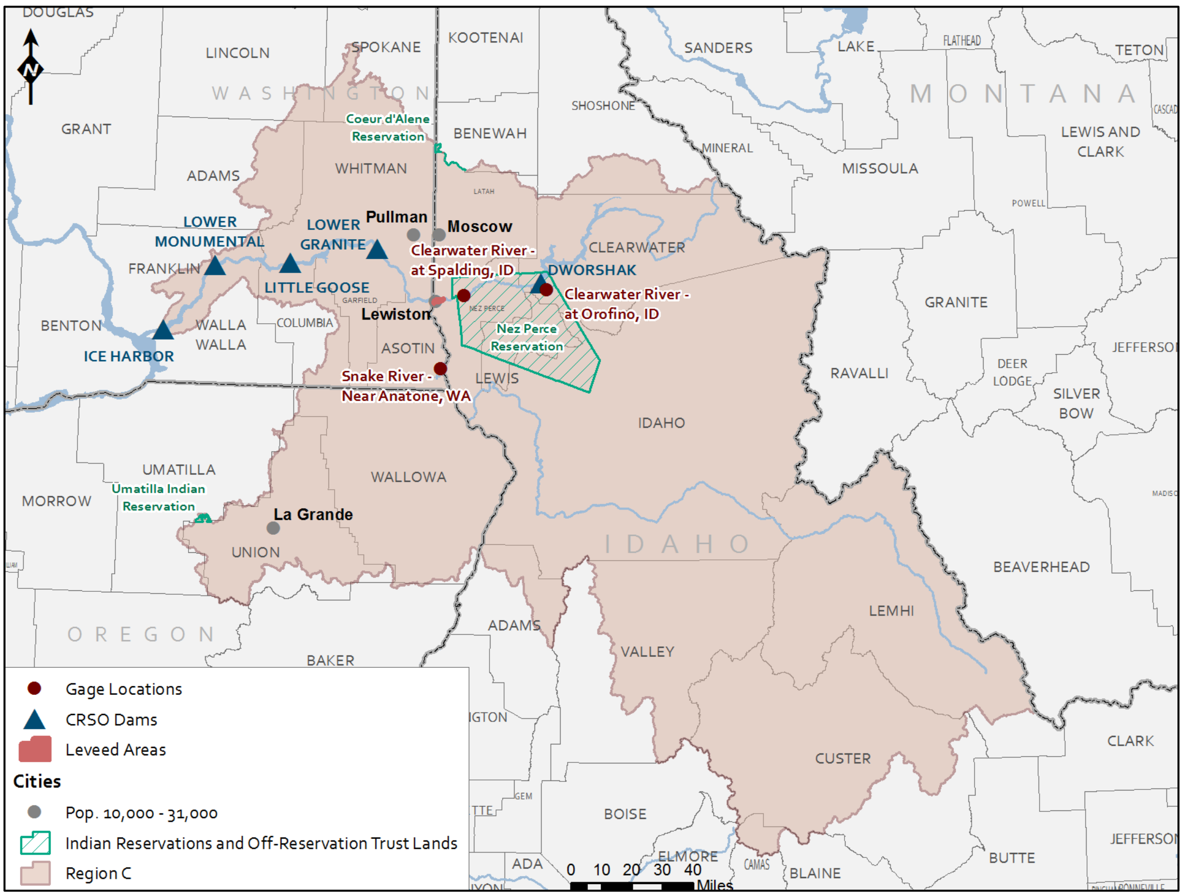


**Figure 3-196. Locations of Columbia River System Dams, Levees, and Other Dams in Region C**

**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) |

The estimated population of communities in Region C is approximately 53,000, of which just over 100 are within the FEMA-defined flood hazard area.[7] The largest population center in the affected area are the cities of Lewiston and Clarkston, Idaho and suburbs. Communities that intersect the study area as well as populations that fall within these flood hazard areas in Region C, are listed in Table 3-220. Region C rural areas include an estimated population less than 2,000 people, of which approximately 90 are located in the flood hazard area. The Nez Perce Tribe has reservation lands in Region C, including an area overlapping with Dworshak.

**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** | | |

[1] Source: U.S. Census Bureau (2017) or latest available data.
[2] Source: ESRI data that is derived from U.S. Census data for unincorporated areas that are census-designated places.
[3] Includes 1% and 0.2% annual chance exceedance flood hazard areas. Populations within the 1% annual chance exceedance (100-year) and 0.2% annual chance exceedance (500-year) flood zones were estimated with geographic information system (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.

#### *3.9.3.4 Region D*

Region D includes the John Day storage project. The river reaches that are relevant to the FRM analysis in Region D are shown in Table 3-221 and are consistent with those utilized in the H&H resources analysis. As noted above, this analysis uses flood gages along a subset of these reaches to characterize current flows and anticipated changes under MOs. Region D includes six gages at Vancouver, Washington; St. Helens, Oregon; Woodland, Washington; Kelso, Washington; Longview, Washington; and Wauna, Oregon. All of these gages are located in Reach 1, which is the reach that contains the majority of the population in this region. Figure 3-197 presents the stream reaches, gages for which flood hazard categories have been 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.

The river communities that fall within Region D and the history of flooding in those communities is briefly summarized as follows:

- R01 extends from the approximately RM 30 of the Columbia River up to Bonneville Dam, and includes the Willamette River up to Willamette Falls. This reach includes the cities of Portland, St. Helens, and Westport, Oregon, and Vancouver, Woodland, Kalama, Kelso and Longview, Washington, as well as many small communities, rural and agricultural areas. Within R01 there are 90,000 acres behind levees. These include 50 systems with 240 miles of levees. This reach has historically flooded many times in the past, with notable catastrophic flooding in 1894, 1948, 1956, 1964, 1996, and 1997.

The R02 consequence area includes the cities of Hood River and The Dalles, Oregon, and Bingen and Lyle Washington. R03 includes Biggs Junction and Rufus, Oregon, and Wishram and Maryhill, Washington. R04 includes Boardman and Umatilla, Oregon, as well as Lake Umatilla.

Region D includes the major metropolitan area of Portland, Oregon, including suburbs, as well as Vancouver, Washington. It also includes the town of Longview, Washington, as well as The Dalles, Oregon. The total population of this area is approximately 1.4 million, with an estimated population within the FEMA-defined flood hazard area of 90,000.[8] The largest population residing in the FEMA-defined flood hazard area is in Longview, Washington, where an estimated population of 33,000 resides in the flood hazard area. An additional 18,000 people in Portland, Oregon, also reside in the flood hazard area. Communities that intersect the study area as well as populations that fall within the flood hazard areas in Region D are listed in Table 3-222. Region D rural areas include an estimated population of 44,000 people, of which 12,000 are located in the flood hazard area. There are also a number of tribes with reservation lands and off-reservation trust lands in Region D, including the Confederated Tribes and Bands of the Yakama Nation, the Cowlitz Indian Tribe, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes of the Umatilla Indian Reservation.

**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.

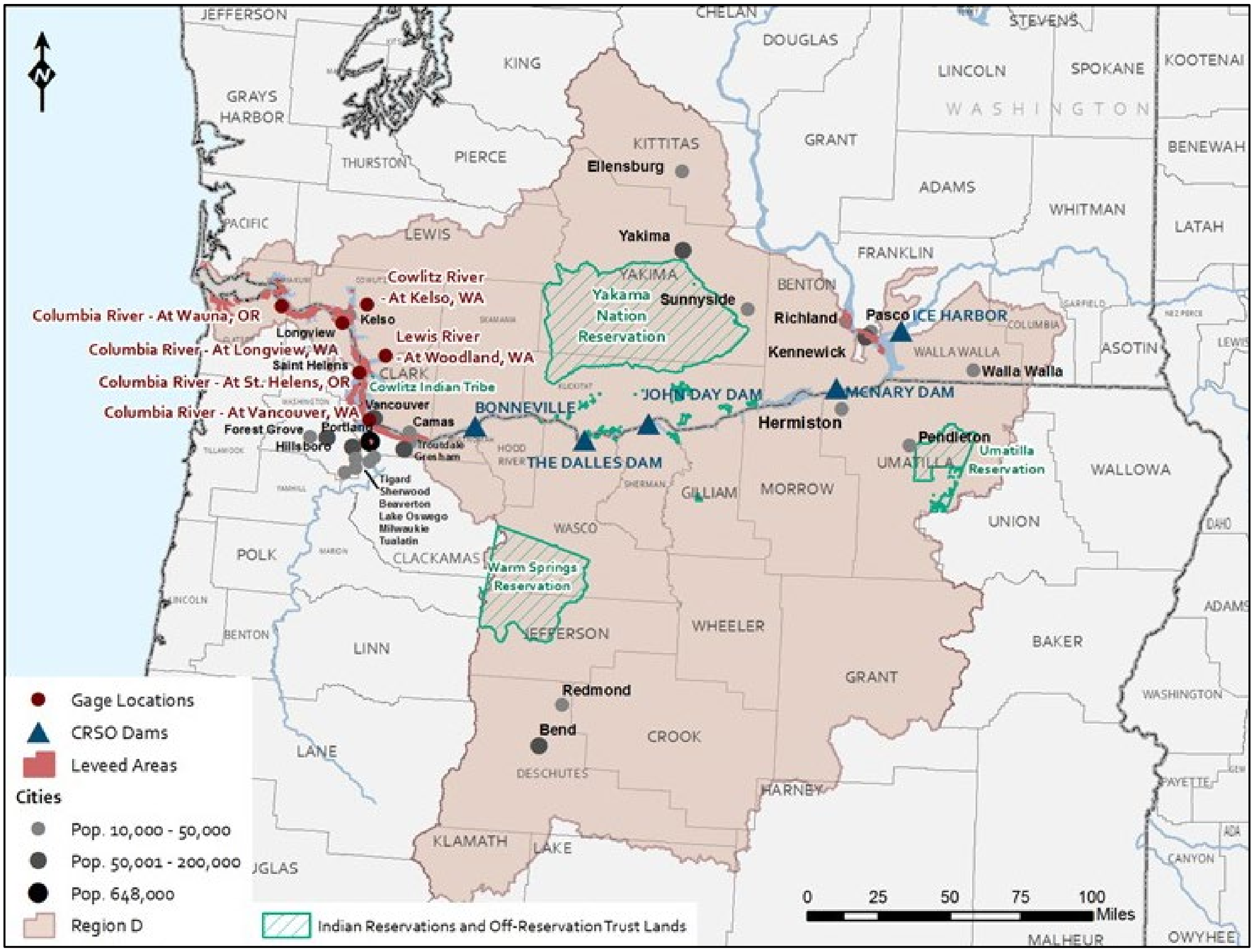


**Figure 3-197. Locations of Columbia River System Dams, Levees, and Other Dams in Region D**

**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 |

| 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 |

| 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** | | |

[1] Source: U.S. Census Bureau (2017) or latest available data.

[2] Source: ESRI data that is derived from U.S. Census data for unincorporated areas that are census-designated places. Some portions of the Tri-Cities area are located in Region B and some are in Region D, but populations reported here for Burbank, Finley and West Richland are only included in Region D (to avoid double counting)

[3] Includes 1% (100-year flood) and 0.2% (500-year flood) annual chance exceedance flood hazard areas. 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.

### 3.9.4 Environmental Consequences

MOs could affect flood risk by changing river flows (measured by discharge in cfs), stages, and reservoir elevations (measured in feet above sea level [NAVD88]), as well as by changing system configuration (as would occur with the breaching of projects on the lower Snake River under MO3). These changes were evaluated to determine whether there would be a change in flood risk faced by communities, property, infrastructure, or levees in the Columbia River Basin under each alternative.

#### *3.9.4.1 Effects Assessment Methodology*

The flood risk analysis began by establishing the anticipated flood risk conditions under the No Action Alternative. Flood risk conditions were evaluated at a sample of gage locations throughout the CRSO study area. Annual peak stages at gage locations (except for Albeni Falls outflow location, where flows were used) were provided by H&H engineers for each of 5,000 simulated events, based on period-of-record data, for each of the winter (November 1 to March 31), spring (April 1 to July 31), and annual (November to July) time periods and for each of the MOs and the No Action Alternative. These peak figures were then compared to thresholds for flood hazards established by the NWS to evaluate whether flood risk would change under the MOs. Hydrologic modeling of anticipated river flows and stages were estimated at each gage for each alternative. Flood risks are measured in terms of the likelihood that established flood thresholds would be exceeded, which is called the annual exceedance probability (AEP).[9]

**LOCATIONS USED IN THIS ANALYSIS**

The analysis used flow and stage estimates at 14 river gages. These gage locations were selected because they provide good representative sample locations throughout the study area. The gages are either located near populated areas or are gage locations commonly used to communicate estimated flood levels for a given area.

The NWS, the U.S. Geological Survey, the Corps, and Reclamation work jointly to gather and disseminate data to inform the public about river conditions at significant locations. The gage location data includes historical stage or flow conditions, which are communicated to the public through the NWS's Advanced Hydrologic Prediction Service (water.weather.gov/ahps). These gages are useful in assessing the thresholds at which river and possible flood conditions become hazardous. The gage locations are shown in Figure 3-192 NWS specifies flows or elevations (stages) that are associated with four different flood categories: action stage, flood stage, moderate flood stage, and major flood stage (defined in Section 3.9.3, *Affected Environment*). The thresholds for each NWS flood hazard category for each gage location are presented in Table 3-223. The thresholds are measured in either elevation (feet) or flow (cfs).

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[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.

**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 | Bonners 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 |

Note: Vertical datum for stages was adjusted to NAVD88 from NWS datum (typically NGVD29) where applicable using National Geodetic Survey conversion factors.
1/ Flow thresholds are in thousands of cfs (kcfs).
2/No threshold defined.
Source:
*3 (A) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=alfw1*
*4 (A) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=plnm8*
*2 (A) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=cfmm8*
*1 (A) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=bfei1*
*5 (B) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=prdw1*
*8 (C) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=anaw1*
*7 (C) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=orfi1*
*6 (C) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=spdi1*
*9 (D) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=vapw1*
*10 (D) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=shno3*
*11 (D) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=lrww1*
*13 (D) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=kelw1*
*12 (D) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=lopw1*
*14 (D) https://water.weather.gov/ahps2/hydrograph.php?wfo=otx&gage=wauo3*

## EVALUATING ANNUAL EXCEEDANCE PROBABILITY FOR FLOOD HAZARDS

For each gage, flood risk changes were identified for the No Action Alternative and each MO using the metric of AEP. As described previously, AEP is the probability of a given river stage or flow (e.g., flood stage) being exceeded in a given year. AEPs were identified at each location for four flood hazard categories (action stage, flood stage, moderate stage, and major stage, as defined in Section 3.9.3, *Affected Environment,*) for the No Action Alternative and each MO. The differences between AEP in each of the MOs and the No Action Alternative were the primary metric used to evaluate changes in flood risk effects. For example, using the flood stage threshold of 1,011.2 feet shown for the Orofino, Idaho, gage in Reach 09 in Table 3-226, the flood stage AEP for the No Action Alternative at this location is 13 percent as shown in Table 3-226. This 13 percent AEP is derived by counting the number of times the stage elevation of 1,011.2 feet is exceeded at this location across the 5,000 events described previously in this paragraph. The same methodology is used to find the AEP for each of the MOs, at each of the NWS thresholds. The AEPs of the multiple objective alternatives are then compared to the AEP of the No Action Alternative to determine if there is any change in AEP between them. For the Orofino, Idaho, gage location used in the example above, Table 8 in Appendix K, *Flood Risk Management*, shows that there is no change in flood stage AEP between the No Action Alternative and MO1.

This analysis uses peak annual and peak seasonal results from the 5,000-run Monte Carlo (M-C) simulations of the ResSim model and the flow-stage transformation tool. These modeling tools are described in detail in Appendix B, *Hydrology and Hydraulics*.

The accuracy of AEP results from the H&H model is uncertain for very rare flooding conditions, defined in this analysis as less than 1 percent AEP. Changes that may occur in the less than 1 percent AEP are described qualitatively, when appropriate. Similarly, changes in AEP at a given location and stage are assumed to be accurate at approximately 1 percent (due to modeling capabilities), thus change values are reported to the whole percent. Additional notes on AEP results, such as limitations of use and model anomalies, are included in Appendix B. Adjustments to the flood risk analysis and results linked to model anomalies are highlighted in Appendix B.

#### *3.9.4.2 No Action Alternative*

Anticipated future flood risk under the No Action Alternative is assumed to be consistent with current conditions, which were modeled using the statistical method described above.[10] The analysis incorporates the historical hydrologic record, adjusted to accommodate additional low probability extreme events, as well as other factors, as described in the Appendix B. The No Action Alternative is intended to be a reasonable approximation of current conditions suitable for the comparative analysis employed in this EIS.

Flood risk, as measured in AEP for each flood hazard category (action stage, flood stage, moderate flood stage, and major flood stage) at each gage location, is described by region and by location in the following sections.

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

As described in Section 3.9.3, *Affected Environment*, Region A is relatively rural, with an estimated total current population of 78,000, and a population of approximately 10,000 within the flood hazard area, most of which reside near Kalispell and Evergreen, Montana.[11] Region A has five gage locations used for this evaluation: Pend Oreille River Outflow from Below Albeni Falls; Lake Pend Oreille near Hope, Idaho; Clark Fork near Plains, Montana; Columbia Falls, Montana; and Bonners Ferry, Idaho. The flood risk AEPs for each flood stage for these gages under the No Action Alternative are summarized in Table 3-224. As shown, the Pend Oreille River Outflow from Below Albeni Falls gage is anticipated to have the highest probability of exceeding the moderate and major flooding thresholds, relative to the other locations shown in the table. Communities near this gage on reach R24 include Clark Fork, Dover, Hope, East Hope, Kootenai, Ponderay, Priest River, and Sandpoint, Idaho. The areas around the Columbia Falls, Montana, gage have a high probability of exceeding flood stage, relative to the other locations 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.

regions, but rather to orient the reader to the table and the probabilities contained therein. Communities around the Columbia Falls, Montana, gage include Kalispell, Montana, and surrounding towns. While there have been some adjustments to Libby Dam operations since the Upper Columbia Alternative Flood Control and Fish Operations Final EIS (Corps, 2006), the current FRM conditions in the Kootenai/y basin as a result of Libby Dam's operation are generally similar to those conditions described in the Upper Columbia Alternative Flood Control and Fish Operations Final EIS.

**Table 3-224. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in 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 | Bonners Ferry, ID | 85% | <1% | <1% | <1% |

Note*:* Modeled estimates are rounded to the nearest whole percentage.
1/ Flow thresholds are in thousands of cfs (kcfs).

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

As described in the Section 3.9.3, *Affected Environment*, Region B is generally rural, with an estimated total current population of 285,000, and a population of approximately 30,000 within the flood hazard area. The largest population center in the affected area is the Kennewick, Washington, (population 81,000), and its suburbs.

Region B has one gage: the Below Priest Rapids, Washington, gage. The flood risk AEPs for each flood stage for this gage under the No Action Alternative are summarized in Table 3-225. As shown, AEP is less than 1 percent for all thresholds at this gage under the No Action Alternative.

As noted in the Table 3-225, the normal full pool elevations in the reaches upstream of Priest Rapids Dam are not exceeded in the simulation. This does not mean those elevations cannot be exceeded, but rather that the No Action Alternative does not affect flood hazards on the Columbia River from Priest Rapids Dam to the U.S.-Canada border.

**Table 3-225. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in 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% |

Note: Modeled estimates are rounded to the nearest whole percentage.

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

As described in Section 3.9.3, *Affected Environment*, Region C has an estimated total current population of 81,000 in 7 communities, but with a population of only 100 people within the flood hazard area. The largest population center in the affected area includes the cities of Lewiston, Idaho, and Clarkston, Washington, and surrounding suburbs.

Region C has three gage locations: Anatone, Washington; Orofino, Idaho; and Spalding, Idaho. The flood risk AEPs for each flood stage for each gage under the No Action Alternative are summarized in Table 3-226. As shown, the Spalding gage on the Clearwater River exhibits the highest risk of moderate and major flooding under the No Action Alternative. However, as noted above, little population resides in the flood hazard area in this region. As shown in the Table 3-226, the normal full pool elevations in reaches R06, R07, and R08 are not exceeded under any alternative simulation. This does not mean those elevations cannot be exceeded, but rather that MOs do not affect flood hazards in these reaches.

**Table 3-226. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in 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% |

Note: Modeled estimates are rounded to the nearest whole percentage.

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

Region D has six gage locations: Vancouver, Washington; St. Helens, Oregon; Woodland, Washington; Kelso, Washington; Longview, Washington; and Wauna, Oregon. All of these gages are located near the Portland metropolitan area or downstream. The flood risk AEPs for each flood stage for these gages under the No Action Alternative are summarized in Table 3-227. The AEP for winter and spring events are shown separately for consequence locations in Region D. Winter events are those modeled to occur from November 1 to March 31, while spring events are those occurring from April 1 to July 31. Winter high-water events are commonly the result of extended periods of precipitation producing historically higher stages but for a lesser duration than spring events. Spring high-water events typically have a longer duration as late-season lower elevation snow is followed by heavy rain. As shown, the gages at Vancouver, Washington, and St. Helens, Oregon, exhibit the highest risk of moderate and major flooding under the No Action Alternative.

As noted in Table 3-227, the normal full pool elevations in reaches R02, R03, R04 and R05 are not exceeded under any alternative simulation. This does not mean those elevations cannot be exceeded, but rather that MOs do not affect flood hazards in these reaches.

**Table 3-227. Flood Risk Annual Exceedance Probabilities under the No Action Alternative in 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% |

Note: Modeled estimates are rounded to the nearest whole percentage.
Source: NWS hydrograph data and H&H analysis

**SUMMARY OF EFFECTS**

An estimated 1.8 million people currently reside in communities that have populations in the flood hazard areas of the CRSO EIS analysis. Of this total, approximately 7 percent reside in flood hazard areas.[12] Most of the total population and population within the flood hazard areas are in Region D.

### *3.9.4.3 Multiple Objective Alternative 1*

This section describes changes in flood risk that would be anticipated under MO1, as measured in terms of changes in AEP from the No Action Alternative. Detailed changes in AEP are 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.

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

There is little change anticipated to AEP in Region A under MO1. Additionally, under some flow conditions, flood risk is anticipated to decrease as a result of a decrease in the probability of flooding (refer to Table 6 of Appendix K, *Flood Risk Management*.

No effect is anticipated to flood risk in the Kootenai River Basin within Region A under MO1. Under typical to lower annual peak flow conditions, flood risk is anticipated to decrease in probability under this alternative. In particular, the probability of flooding at Bonners Ferry, Idaho, is anticipated to decrease by 6 percent under MO1 at the action stage. This is due to a variety of operational measures at Libby Dam that result in deeper drafts earlier in the spring, including the *Modified Draft at Libby* measure. There are negligible changes to the probability of higher flood stage at the Bonners Ferry gage, thus no effect to flood risk conditions are expected. The U.S.-Canada border is downstream of Bonners Ferry. No effect to Canada is anticipated under MO1.

On the Flathead River below Hungry Horse Dam, operational changes related to the *Hungry Horse Additional Water Supply* measure result in slightly decreased AEP at Columbia Falls, Montana, at the action and flood stage levels (of 1 to 2 percent) but negligible changes in probability at the larger flood stages leading to no effect on flood risk conditions.

Related to the change at Hungry Horse, some minor decreases in flood risk (1 to 2 percent) are evident in the action and moderate flood conditions on the Pend Oreille River outflow from below Albeni Falls. There are no changes in flood risk at the Clark Fork gage near Plains, Montana, for any of the alternatives. Detailed tables are presented in Appendix K, *Flood Risk Management*. No effect to the Canadian part of the Pend Oreille is anticipated under MO1.

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

No changes to flood risk are anticipated in Region B under MO1.

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

No changes to flood risk are anticipated in Region C under MO1.

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

Under MO1, it is anticipated that there are minor decreases in flood risk in Region D. In particular, there are negligible changes at the action stages and minor decreases at higher flood stages. Due to the *Winter System FRM Space* measure at Grand Coulee Dam, which results in more storage in December and January in order to reduce Columbia River flows coincident with peak flood conditions in the Portland/Vancouver area in reach R01, winter and annual peak flows are 1 to 4 percent lower for larger flood conditions near the mainstem Columbia River. The Vancouver, Washington, gage shows a decrease in flood risk at the action and flood stages of 1 to 2 percent. Similar decreases are seen downstream at the St. Helens, Oregon, and

Longview, Washington, gages. Changes in flood risk at the Woodland and Kelso, Washington, gages would be similar to but likely smaller than those on the mainstem Columbia River downstream.[13] Detailed tables are presented in Appendix K, *Flood Risk Management*.

**SUMMARY OF EFFECTS**

No increases in flood risk are anticipated as a result of MO1. Minor decreases in flood risk are expected in some areas, especially Region D. The primary measure that causes this decrease would be the *Winter System FRM Space* measure.

### *3.9.4.4 Multiple Objective Alternative 2*

This section describes changes in flood risk, as measured in terms of changes in AEP from the No Action Alternative, for MO2. Detailed changes in AEP are presented in Appendix K, *Flood Risk Management*.

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

Overall, there is little change to flood risk anticipated under MO2 in Region A. Changes in flood risk in the Kootenai River Basin under MO2 are expected to be similar to those under MO1. At the Bonners Ferry, Idaho, gage, negligible changes are expected at flood stages, and there is a 7 percent decrease expected in AEP at the action stage primarily due to the *Modified Draft at Libby* measure. There are no anticipated changes in flood risk in the Flathead and Pend Oreille River Basins under MO2.[14] No effect to Canada is anticipated downstream of Bonners Ferry under MO2. No effect to the Canadian part of the Pend Oreille is anticipated under MO2.

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

No changes to flood risk are anticipated under MO2 in Region B. Detailed tables are presented in Appendix K, *Flood Risk Management*.

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

Some changes in flood risk are anticipated under MO2 in Region C, although the changes are minor and would primarily affect AEP at lower action levels. The *Slightly Deeper Draft for Hydropower* measure would result in increased outflow from Dworshak, which would result in

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[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.

higher peak flows during typical, non-flood years. No changes in AEP are expected during potential flood years.[14] Detailed tables are presented in Appendix K, *Flood Risk Management*.

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

There is little change anticipated to flood risk in Region D under MO2. Changes in flood risk in Region D under MO2 are anticipated to be similar to those under MO1, largely due to the *Winter System FRM Space* measure at Grand Coulee Dam. This measure results in more storage in December and January in order to reduce Columbia River flows coincident with peak flood conditions in the Portland/Vancouver area in reach R01. As a result, winter and annual peak flows are 1 to 4 percent lower for larger flood conditions near the mainstem Columbia River. The Vancouver, Washington, gage shows a decrease in flood risk at the action and flood stages of 1 to 2 percent, and negligible changes at the moderate and major flood stages. Similar changes are seen downstream at the St. Helens, Oregon, and Longview, Washington, gages. Changes in flood risk at the Woodland and Kelso, Washington, gages would be similar to but likely smaller than those on the mainstem Columbia River downstream.[15] Detailed tables of AEP changes are presented in Appendix K, *Flood Risk Management*.

**SUMMARY OF EFFECTS**

No increases in flood risk are anticipated as a result of MO2. Some modeling anomalies related to refill logic in the model appear to show minor increases at the Columbia Falls, Montana, gage. However, 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. Minor decreases in flood risk are expected in some areas, especially Region D.

### *3.9.4.5 Multiple Objective Alternative 3*

This section describes changes in flood risk, as measured in terms of changes in AEP from the No Action Alternative, for MO3. Detailed changes in AEP are presented in Appendix K, *Flood Risk Management*.

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

There is little change to flood risk anticipated under MO3. Additionally, under some flow conditions, as shown in Table 14 of Appendix K, *Flood Risk Management,* flood risk is anticipated to decrease in probability at some locations. In particular, the risk of flooding at Bonners Ferry, Idaho, is anticipated to decrease by 7 percent under MO3 at the action stage. Flood risk is anticipated to be reduced by 1 percent at the action stage and 2 percent at the 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.

*Management*. No effect to Canada is anticipated downstream of Bonners Ferry under MO3. No effect to the Canadian part of the Pend Oreille is anticipated under MO3.

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

No changes to flood risk are anticipated in Region B under MO3.

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

MO3 would generally reduce river stages from the draining of Lower Granite Reservoir and the breaching of the other lower Snake River dams. Recognizing that levees exist at Clarkston and Lewiston, it is expected that when river stages decrease, flood risk would also decrease. Additional analysis would be required as part of an engineering design study to determine future levee needs and associated O&M requirements. Overall, in Region C under MO3, no effect to flood risk is expected.[16] Detailed tables are presented in Appendix K, *Flood Risk Management*. There are levees at Clarkson and Lewiston that are intended to contain the Snake and Clearwater Rivers (including flood flows) and prevent flooding within the cities. These levees were built as part of the Lower Granite project, which does not have an FRM project purpose. The levees have been referred to informally as flow conveyance levees and were designed to prevent flooding within the cities when the Lower Granite pool was filled in the 1970s. The area behind the levees contains highly developed industrial, commercial, and residential property

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

There is little change anticipated to flood risk in Region D under MO3. Due to the *Winter System FRM Space* measure at Grand Coulee Dam, which results in more storage in December and January in order to reduce Columbia River flows coincident with peak flood conditions in the Portland/Vancouver area in reach R01, winter and annual peak flows would be lower for larger flood conditions near the mainstem Columbia River. Under flow conditions at some locations as shown in Table 17 of Appendix K, *Flood Risk Management*, flood risk is anticipated to decrease in probability by 1 to 2 percent. Table 17 also shows estimates that flood risk may increase by 1 percent at the Wauna, Kelso, and Woodland gages in some flood conditions; however, this slight increase is likely due to model anomalies. [17] Detailed tables for all alternatives and gage locations are presented in Appendix K, *Flood Risk Management*.

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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.

**SUMMARY OF EFFECTS**

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. The Spalding, Idaho, gage shows a minor increase in flood risk at the action stage, while minor decreases in flood risk may occur in other areas.

#### *3.9.4.6 Multiple Objective Alternative 4*

This section describes changes in flood risk, as measured in terms of changes in AEP from the No Action Alternative, for MO4. Detailed changes in AEP are presented in Appendix K, *Flood Risk Management*.

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

There is little change anticipated to AEP in Region A under MO4. Additionally, under flow conditions at some locations as shown in Table 18 of Appendix K, *Flood Risk Management*, flood risk is anticipated to decrease in probability. At the Pend Oreille River Outflow from Below Albeni Falls gage, a 1 percent increase for the action and major flood stages is anticipated under this alternative. The risk of flooding at Bonners Ferry, Idaho, is anticipated to decrease by 5 percent under MO4 at the action stage primarily due to the *Modified Draft at Libby* measure. Detailed tables are presented in Appendix K, *Flood Risk Management*. The risk of flooding at the flood stage is anticipated to decrease by 2 percent at the Columbia Falls, Montana, gage. No effect to Canada is anticipated downstream of Bonners Ferry under MO4. No effect to the Canadian part of the Pend Oreille is anticipated under MO4.

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

No changes to flood risk are anticipated in Region B under MO4.

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

No effect to flood risk is expected in Region C under MO4. At the Spalding, Idaho, gage, flood risk modeling shows no change. Detailed tables are presented in Appendix K, *Flood Risk Management*.

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

There is little change anticipated to flood risk in Region D under MO4. Changes in flood risk in Region D under MO4 are anticipated to be similar to those under MO1, largely due to both alternatives including the *Winter System FRM Space* measure at Grand Coulee Dam. This measure results in more storage in December and January in order to reduce Columbia River flows coincident with peak flood conditions in the Portland/Vancouver area in reach R01. As a result, winter and annual peak flows are 1 to 4 percent lower for larger flood conditions near the mainstem Columbia River. The Vancouver, Washington, gage shows a decrease in flood risk at the action and flood stages of 1 to 2 percent, and negligible changes at the moderate and major flood stages. Similar changes are seen downstream at the St. Helens, Oregon, and Longview, Washington, gages. Changes in flood risk at the Woodland and Kelso, Washington, gages would be similar to but likely smaller than those on the mainstem Columbia River downstream.[18] Detailed tables of AEP changes are presented in Appendix K, *Flood Risk Management*.

**SUMMARY OF EFFECTS**

No changes flood risk are anticipated as a result of MO4. Minor decreases in flood risk may occur in some areas, especially in Region D.

### 3.9.5 Tribal Interests

There are also a number of tribes with reservation lands and off-reservation trust lands in the study area, including the Kootenai Tribe of Idaho, the Confederated Salish and Kootenai Tribes, and the Kalispel Tribe of Indians in Region A; the CTCR, the Spokane Tribe of Indians, and the Coeur d'Alene Tribe in Region B; Nez Perce in Region C, the Confederated Tribes and Bands of the Yakama Nation, the Cowlitz Indian Tribe, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes of the Umatilla Indian Reservation in Region D.

Analysis of flood risk (Section 3.9.4) indicates that overall there would be no change to flood risk in the study area under any MO relative to the No Action Alternative. As such, there would 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.

## 3.10 NAVIGATION AND TRANSPORTATION

The MOs have the potential to affect commercial navigation activities, commercial cruise line and ferry operations, and the broader transportation system, including roads and railways. Dredging and other ongoing maintenance of the navigation channel may also be affected by implementation of the alternatives. This section describes these activities and potential effects.

### 3.10.1 Introduction and Background

River navigation has provided a means of transportation, trade, commerce, and economic development in the Northwest dating back to the original Native American occupants thousands of years ago. The natural flow of the river presented significant challenges for navigation and transportation on the river, given the wide fluctuations in water volumes between the dry summer months and the winter/spring melt. The construction of the locks/dams on the Columbia and Snake Rivers, beginning in 1933 on Bonneville Dam and ending in 1975 with Lower Granite on the Snake River, allowed for safer operation of large vessels, lower transportation costs, and more consistent river conditions.

The inland river navigation on the Columbia and Snake Rivers has served an important role in the overall, multi-modal transportation system in the Columbia River basin. Barge transportation is ideally well-suited for movement of large quantities and for heavy commodities. Barges can accommodate bulky, oversized shipments that would be challenging to move by rail and/or road. Additionally, barges have low-energy demands, requiring less fuel per ton of commodity shipped compared to alternate shipping modes.

The presence of inland water transportation and the multi-modal system serves both complementary and competitive forces for businesses and shippers moving freight. It is complementary given that all volumes of commodities that move on the river system begin and end somewhere beyond the river, requiring other modes of transport, such as truck and rail, for river transport to exist or be viable. This is evident for much of the grain products that move down the Snake River that originate via truck or rail. It is competitive by providing an alternative option for freight to use different multi-mode combinations, thereby applying competitive market pressure to lower transportation rates, while continuing to provide a valuable service.

Many changes have occurred over time to the combination of freight services and the commodity mix of freight moving on the different segments of this river system. The lower Columbia River, with 43-foot draft, allows for bulk ocean and container carrier vessels and, until 2015, was also a primary conduit for container freight accessing the Port of Portland's Terminal 6. Prior to 2015, several ocean container lines called on the Port of Portland, including the South Korean carrier, Hanjin; the German-based carrier, Hapag-Lloyd; Puyallup, Washington-based Westwood Shipping; and others. The freight moving in these containers was primarily consumer durables, inbound containers arriving from Asia. Outbound export commodities included hay, paper products, frozen potatoes, dried fruit, and other high-value agricultural products. After 2015, the decision by the ocean container carriers to cease calling on the Port of

Portland was due to a variety of factors, but was accelerated by an extended labor dispute between the International Longshore and Warehouse Union and the terminal operator that led to slow loading and unloading of ships and costly stops. It was also partly due to the evolution of the industry to begin using larger container vessels that required drafts too deep for the Columbia River ports. As a result, all of the container freight that previously moved through the Port of Portland recently shifted to the Ports of Tacoma and Seattle, Washington (Northwest Seaport Alliance 2018). However, it was recently announced that weekly container service using six 4,300 to 4,500 20-foot-equivalent-unit (TEU) vessels, will resume service in early 2020 at the Port of Portland. The full port rotation will be Yantian, Ningbo, Shanghai, Pusan, Vancouver, Seattle, Portland, Pusan, Kwangyang, and Yantian. While no service to the Snake River is currently anticipated, the potential exists for future expansion of this service (Port of Lewiston 2019).

While the loss of container services reduced container vessel freight moving on the lower Columbia and Snake Rivers, other changes led to significant increases in bulk ocean grain vessels calling at the lower Columbia River export terminals. Until the early 2000s, most of the grain being exported out of the Northwest arrived via barge (and some rail) out of the lower Columbia River, with primarily wheat exports using barge transport down the Snake River. The advent of the shuttle grain train (dedicated 110-unit hopper grain trains) and the increasing demand for protein in Asia (primarily China) led to several large investments by international grain merchants on the lower Columbia River as well as increasing volumes of soybeans, corn, wheat, and dried distillers grains being exported from the lower Columbia River ports while originating throughout the Midwest by rail. Soybean exports alone from Northwest ports increased from just below 40 million bushels in 1998 to 450 million bushels by 2016 (USDA Grain Inspections 2018).

The primary grain export terminals receiving shuttle trains from the Midwest on the lower Columbia River include:

- **Longview Export Grain Terminal, Longview, Washington**. A $230 million facility expansion was completed in 2012. It can accommodate six 110-car trains at any given time.
- **Kalama Export Company & Pacificor, LLC, Kalama, Washington**. A $36 million facility upgrade was completed in 2011.
- **TEMCO LLC, Kalama, Washington**. A $100 million expansion was completed in 2015.
- **United Grain, Vancouver, Washington**. A $72 million facility upgrade completed in 2013.
- **Columbia Grain, Portland, Oregon**. A $44 million facility upgrade was conducted in 2011.

The volume of barge freight moving between Portland, Oregon, and Pasco, Washington, is more than double the volume of freight moving on the lower Snake River, but both sections of that river have experienced declines in barge freight volumes, particularly in the past 10 years. Generally speaking, upriver freight movements are primarily serving to deliver inputs such as fuel, fertilizer, chemicals (agricultural industry), aggregates and steel (construction industry), whereas downriver barge movements have provided export gateways for products produced in the Northwest, primarily bulk grain (wheat) and forest products.

Specific to the lower Snake River, total downriver tonnage decreased from 4.5 million tons in the year 2000 to 2.8 million tons in 2018 (Figure 3-198). However, within the past four years, total downriver shipments have somewhat rebounded. These increases are evident in Table 3-228, where the shipment of farm products has increased from 2.3 million in 2015 to 2.4 million in 2018. Upriver shipments, predominantly fuel, also decreased from 2.2 million in 2000 to 1.1 million in 2018.

On the Snake River, grain comprises the vast majority (more than 87 percent) of shipments on the lower Snake River. The total volume of these other commodities is relatively small; however, the system provides unique services associated with these commodities.

- **Fuel and Other Petroleum Products**. Primarily an upriver movement that ends above McNary Dam near Pasco, fuel and other petroleum products travel via barge on the shallow-draft system. Fuel is the largest commodity shipped on the lower Snake River, comprising 91 percent of upbound tonnage in 2018, and 27 percent of the overall tonnage shipped on the river (Waterborne Commerce 2020). Until 2012, fuel was shipped further upriver to Wilma, but has not been shipped in recent years to that location (Tidewater Barge Lines 2020). As such, little fuel movements currently occur on the lower Snake River above Ice Harbor Dam.
- **Wood Chips**. Wood chips travel both upriver and downriver in relatively small volumes in service of papermills that are located on or near the lower Snake River (approximately 100,000 tons in 2018, representing 3 percent of all volume on the lower Snake River). In particular, a papermill in Lewiston receives regular shipments of wood chips.
- **Oversized Objects**. The Columbia-Snake River Navigation System (CSNS) provides a unique water route to transport oversized cargo into the interior of the United States. Cargo transported upriver to the Port of Lewiston can then be transported on U.S. Highway 12, which has no cargo height restrictions. U.S. Highway 12 has no overpasses and similarly there are routes in Montana that have no height restrictions. (Idaho Cooperating Agencies 2020). While the system transports shipments of this type infrequently, it is a unique service that could not be replaced by road or rail alone.

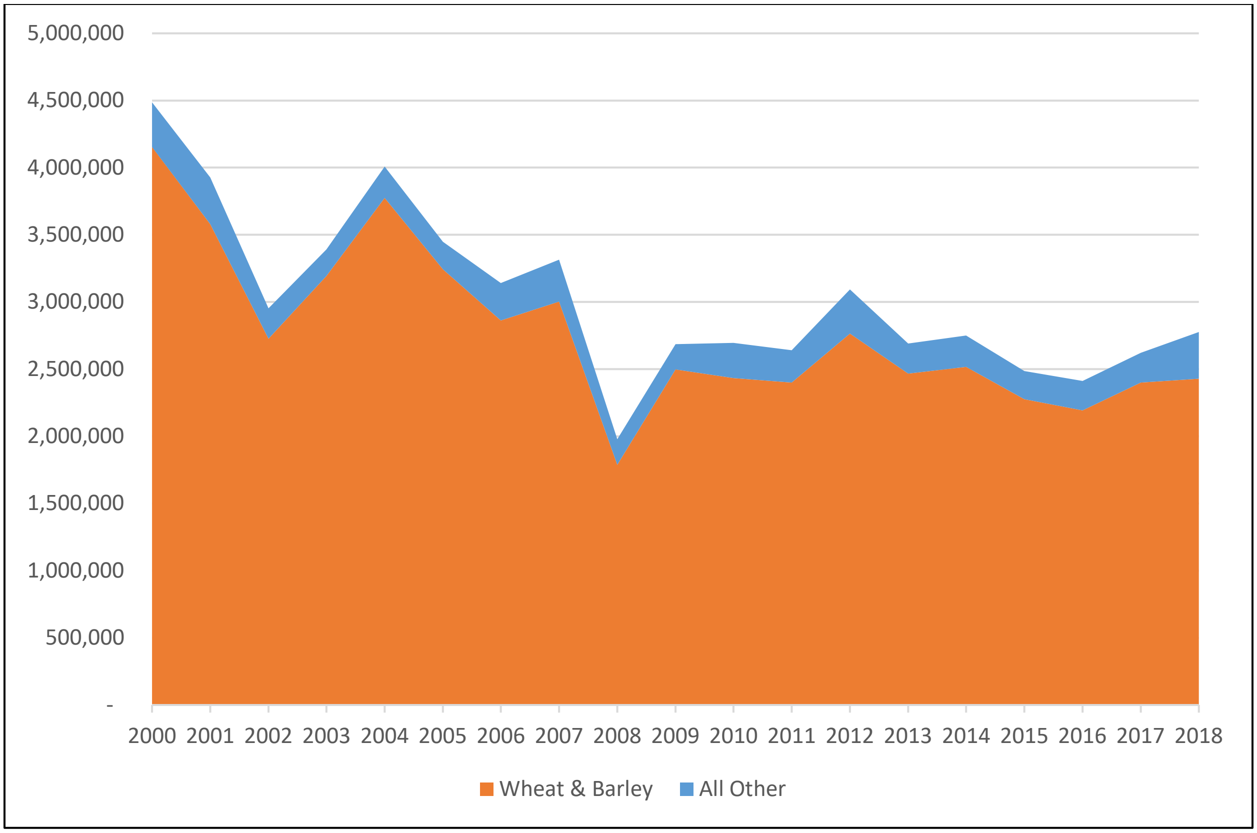



**Figure 3-198. Downbound Freight Shipments on the Snake River, 2000 to 2018, Tons**

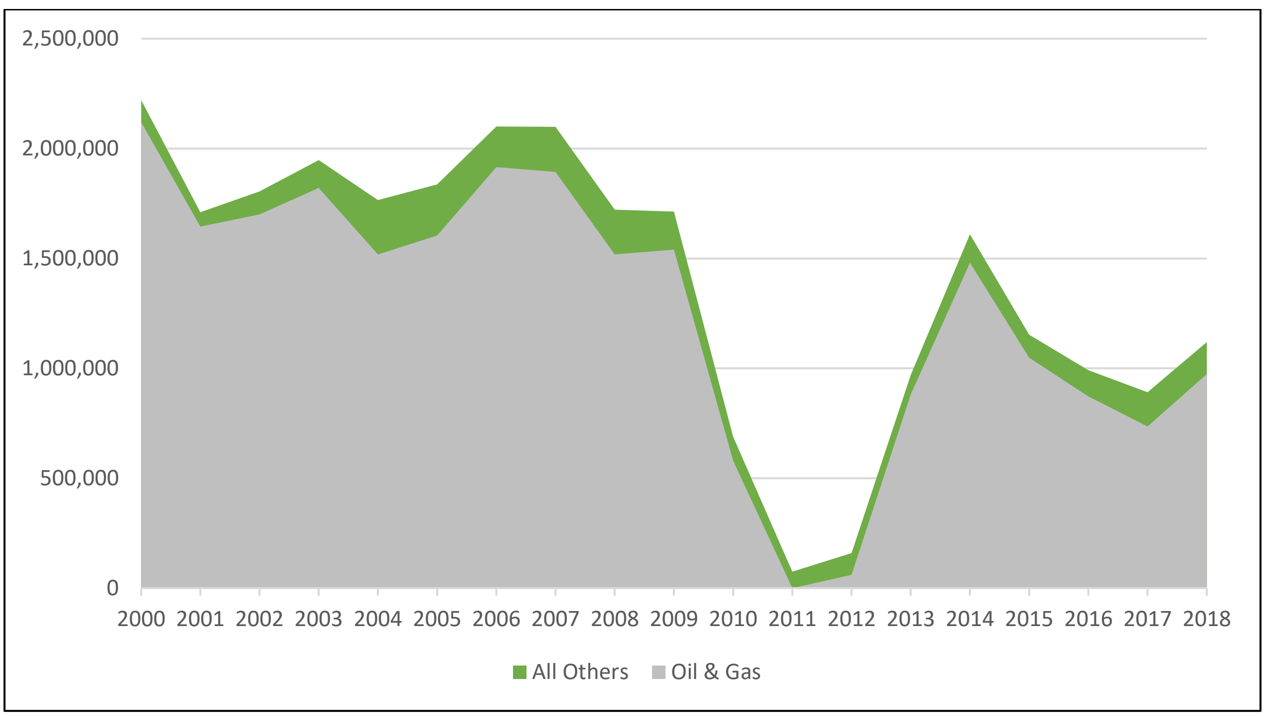



**Figure 3-199. Upbound Freight Shipments on the Snake River, 2000 to 2018, Tons**

**Table 3-228. Snake River Freight Volumes by Direction, 2015 to 2018, Thousand Tons**

| | 2015 (thousand tons) | | | 2016 (thousand tons) | | | 2017 (thousand tons) | | | 2018 (thousand tons) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Commodity** | **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** |

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.
2/ *Not displayed as there are less than three operators as required by Federal Trade Secrets Act, 18 U.S.C. § 1905.
Note: Totals may not sum due to rounding.
Source: Corps Waterborne Commerce Statistics (2020)

#### *3.10.1.1 Area of Analysis*

Because it is an important thoroughfare for goods shipping to international ports, MOs that affect shipping on the Columbia and lower Snake River system could have national implications. However, the majority of effects to the CRS navigation and transportation area of analysis would be experienced within the Columbia River Basin and, particularly, in Regions C and D. There are no anticipated effects to navigation and transportation in Canada under any alternative.

The CSNS is the federally authorized navigation channel that stretches 470 miles and follows the navigable reaches of the lower Snake River beginning near Lewiston, Idaho and Clarkston, Washington, to its confluence with the Columbia River near Pasco, Washington, and then on the Columbia River to its confluence with the Pacific Ocean near Astoria, Oregon. The CSNS consists of three primary segments: (1) a 43-foot deep-draft segment between the Pacific Ocean and Portland, Oregon, and Vancouver, Washington (RM106) in Region D, (2) a 28-foot segment (maintained at 17 feet) of the Columbia River between Vancouver, Washington and The Dalles, Oregon in Region D, and (3) a 14-foot shallow-draft section of the Columbia River, which stretches from The Dalles to Pasco, Washington, in Region D, to the Snake River RM 140 at Lewiston, Idaho, and Clarkston, Washington (Figure 3-200). The area of analysis for river ferry transportation includes Lake Roosevelt at the Grand Coulee project in Washington and the Westport Slough of the lower Columbia River. The Lake Roosevelt ferry transportation occurs within Region B, while the Westport Slough ferry transportation is within Region D. There are no proposed measures within the MOs that would potentially impact navigation or transportation within Region A compared to the No Action Alternative; therefore, Region A is 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**

## 3.10.2 Affected Environment

### *3.10.2.1 Commercial Navigation and Transportation Systems*[1]

Commercial vessels are "used in transporting by water, either merchandise or passengers for compensation or hire, or in the course of business of the owner, lessee, or operator of the vessel." (33 C.F.R. 207.800) As such, commercial navigation on the CSNS includes shipping, cruise lines, ferry services, as well as other vessels used for hire.

**FEDERAL NAVIGATION SYSTEM**

Between 50 to 60 million tons of cargo is transported through the CSNS each year (Corps Waterborne Commerce Statistics 2018). As an import/export gateway, the CSNS is vital to the regional economy. There are no west coast rail or highway routes that offer transport of cargo without height or weight restrictions into the interior of the United States comparable to the CSNS.

In addition, the navigation system is used by the public for recreational boating, which links to the navigation and recreation missions and stewardship of the co-lead agencies. This section describes commercial navigation activities for deep-draft and shallow-draft reaches of the Federal Navigation Channel (FNC).

**Deep-Draft Navigation Channel**

A 43-foot draft navigation channel is maintained on the lowermost 106 miles of the Columbia River from Vancouver, Washington, to the Pacific Ocean. The Columbia River channel serves multiple deep-water ports as an integrated system along the lower 106 river miles. It is the primary pathway for the deep-draft channels of the CSNS; however, tributary streams and waterways such as the Cowlitz River, Lewis River, Willamette River, and Oregon Slough provide important access to the Columbia River and eventually the Pacific Ocean. In fact, much of the Port of Portland is on the Willamette River, which joins the Columbia River near RM 102. Access to the Pacific Ocean requires traversing a series of sandbars and shoals that occur at the mouth of the Columbia River, referred to as "the Bar." A deep-draft channel through the Bar is maintained by annual dredging by the Corps, Portland District. Sediment movement, shoaling, and sand waves form commonly at other locations between the Bar and RM 106 (where the shallow-draft channel begins), especially in tight river bends and at the mouth of tributary streams, which requires dredging to maintain authorized channel depths.

**Shallow-Draft Navigation Channel**

From Vancouver, Washington (RM 106) to The Dalles Dam, the authorized channel is 27 feet deep and 300 feet wide; however, the channel is typically dredged only to 17 feet deep up to the Bonneville Dam and 14 feet deep between the Bonneville Dam and Dalles Dam, reflecting 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.

remaining CSNS shallow-draft segment stretches from The Dalles to near Lewiston, Idaho on the Snake River (Snake RM 140) and is authorized for a 14-foot-deep and 250-foot-wide channel. Altogether, the inland portion of the CSNS covers the entire 470-mile-long water highway formed by the eight mainstem dams and lock facilities on the lower Columbia and Snake Rivers. The waterway provides inland waterborne navigation up and down the river from Lewiston, Idaho, to the Pacific Ocean. This system is used for commodity shipments from the Northwest to both domestic and international markets.

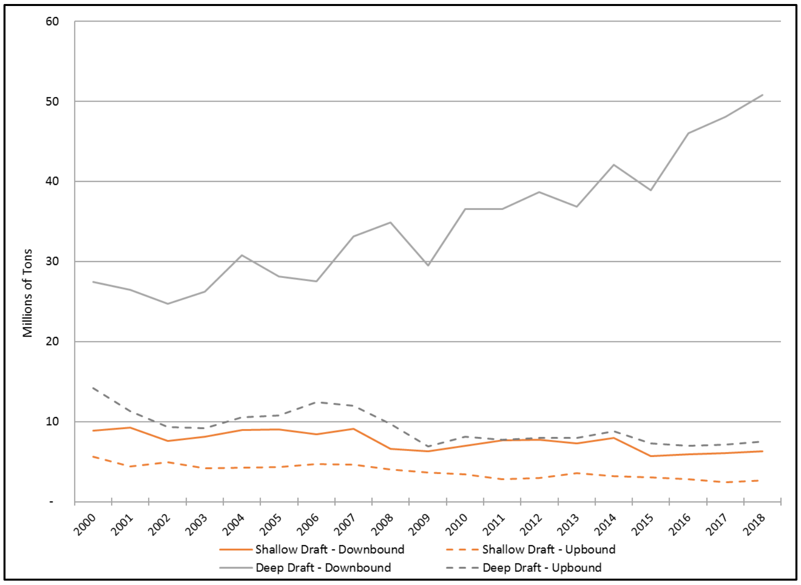
### CURRENT AND HISTORICAL TONNAGE

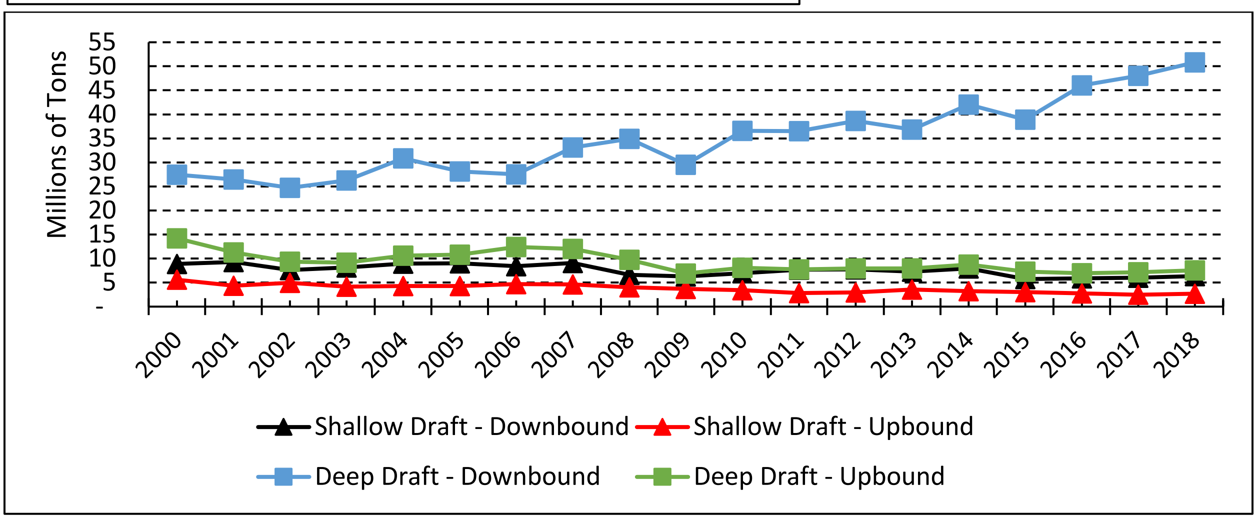
Over the past 20 years, total cargo moved on the CSNS ranged between a recession-year low of 46.4 million tons in 2009 to a high of 67.4 million tons in 2018 (Figure 3-201).

**Table 3-229. Columbia-Snake Navigation System Tonnage, 2000 to 2018**

| | Million Tons | | |
|---|---|---|---|
| **Year** | **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% |

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.
Source: Corps Waterborne Commerce Statistics (2020)



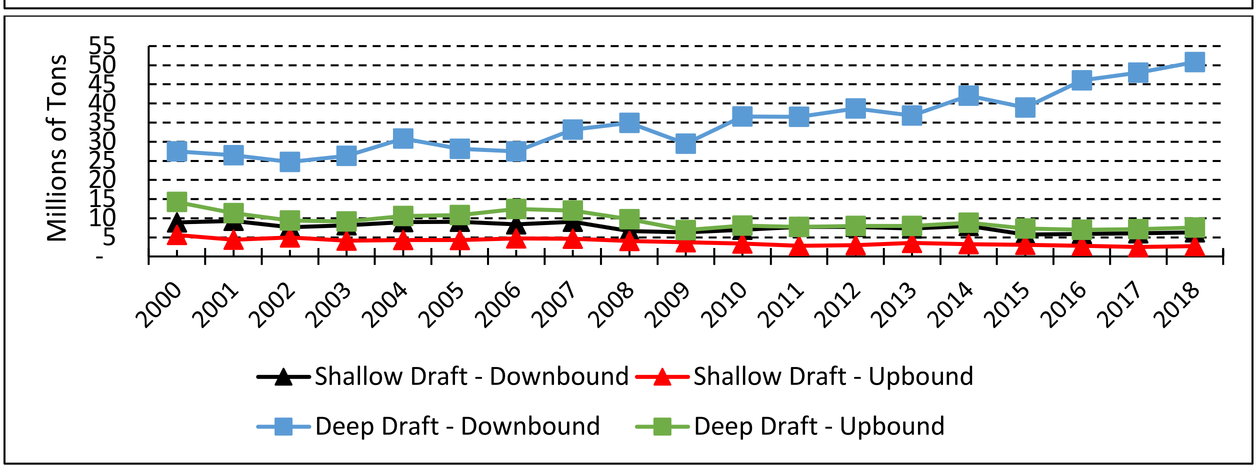




**Figure 3-201. CSNS Deep and Shallow Draft Freight Tonnage (2000 to 2018)**

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.

Source: Corps Waterborne Commerce Statistics (2020)

Food products dominate the tonnage on the CSNS. Of the total commodities moving on the CSNS, shown in Figure 3-202, food products account for over 56 percent of the average 61.9 million tons that moved on the CSNS between 2014 and 2018. Of these, wheat was the top commodity with an average of 17.3 million tons (29.7 percent) moving on the CSNS between 2012 and 2016. Along with agricultural commodities, the most common movements on the system between 2014 and 2018 included: chemicals (12.4 percent), “others” (12.0 percent), petroleum and products (8.0 percent), aggregates (7.3 percent), iron and steel (3.1 percent), and ores and minerals (1.2 percent). While most of the aggregates (i.e., pebbles, gravel, and other raw materials) and wood chips (encapsulated within “others”) move intra-waterway, potassium sodium carbonate and chloride fertilizers are bound for export.

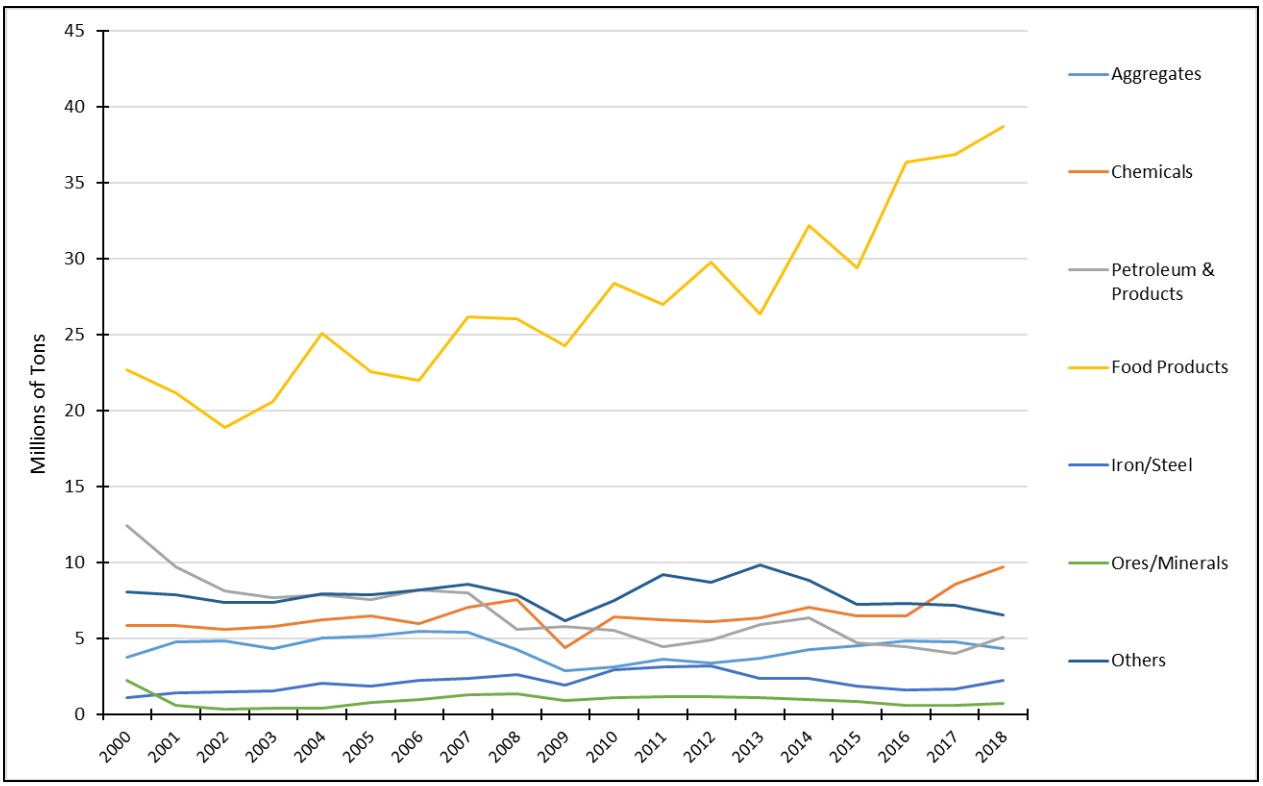



**Figure 3-202. Top 10 Commodities (Deep Draft and Shallow Draft) Moving on the CSNS, 2000 to 2018**

Note: Rankings are based on average tonnage from 2012 to 2018.

Source: Corps Waterborne Commerce Statistics (2020)

The next two subsections discuss the deep-draft and shallow-draft commerce on the CSNS.

### Deep-Draft Navigation Channel

There are four major deep-water ports on the CSNS engaged in coastal and international trade: Portland, Oregon; Kalama, Oregon; Longview, Washington; and Vancouver, Washington (Figure 3-203). In 2016, these four ports ranked in the top 100 U.S. ports in tonnage terms. Portland, Oregon, ranked 32nd; Kalama, Washington, ranked 41st; Longview, Washington, ranked 44th; and Vancouver, Washington, ranked 54th. The Ports of Astoria, Oregon, and St. Helens, Oregon, also handle significant amounts of cargo. Exports dominated the traffic in each of these ports. Only the Gulf-Intracoastal Waterway (with 8 ports), the Lower Mississippi (with 5), and Puget Sound (with 3) had as many or more ports ranking in the top 50 as the CSNS.

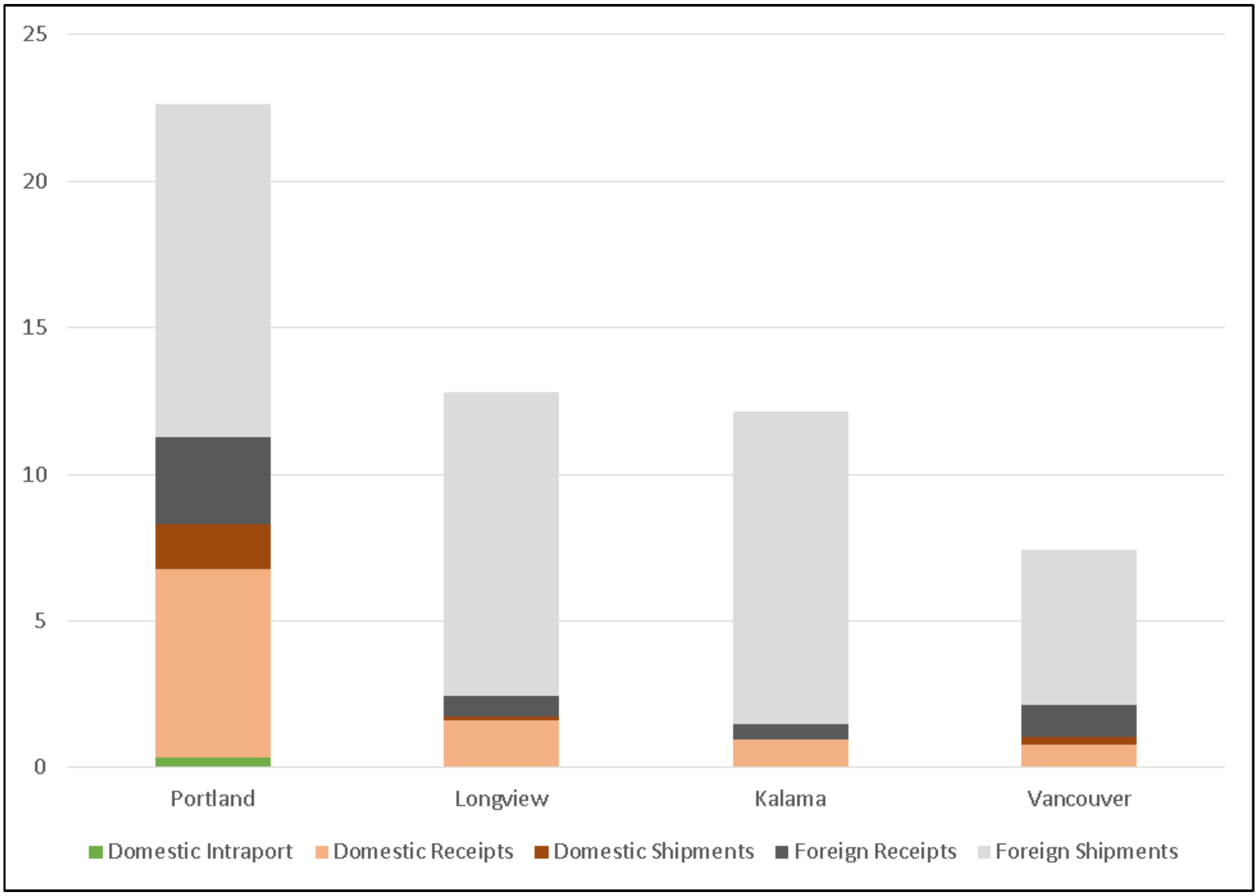



**Figure 3-203. Tonnage at Major Deepwater Ports on the CSNS (average 2012 to 2016, millions of tons)**

Note: Totals may not sum due to rounding.

Source: Corps Waterborne Commerce Statistics (2018)

**Shallow-Draft Navigation Channel**

Shallow-draft (less than or equal to 14-foot draft) traffic moves on the CSNS along the roughly 355 miles of waterway between Portland, Oregon, and the Clarkston, Washington–Lewiston, Idaho, area. In 2018, 8.6 million tons of traffic moved by shallow-draft barge on the CSNS, of which 3.9 million tons travelled on the Snake River.

The majority (71 percent) of freight traffic on Snake River moves in the downstream direction (Figure 3-204). Though wheat tonnage decreased after 2014, wheat continues to account for greater than 87 percent of tonnage moving downstream on the Snake River. The main commodities moving upstream on the Snake River are petroleum products, particularly gas and oil.

Traffic on the CSNS generally builds in volume moving from uppermost Lower Granite Dam to Bonneville Dam on the lower Columbia River. As shown in Figure 3-203, the traffic on the Snake River is approximately half of the levels on the Columbia River. The timber and agricultural-based economies in the interior Northwest rely on the CSNS to reach international markets. Figure 3-204 shows food products group which includes wheat moving the length of the river through each lock in the CSNS. Logs and woodchips, classified under the “others” group, also move the length of the river.

also shows the upbound flows of petroleum products (fuel) and chemicals (fertilizers), contained in the chemicals grouping, through the Columbia River locks. As discussed above, fuel transport drops off above McNary Dam. Iron and steel, as well as waste materials and manufactured equipment and machinery, contained in the “others” group, move primarily through the lowermost three locks on the Columbia River reach of the CSNS. Note that in Figure 3-198, the McNary pool includes freight on the lower Columbia as well as the lower Snake River.

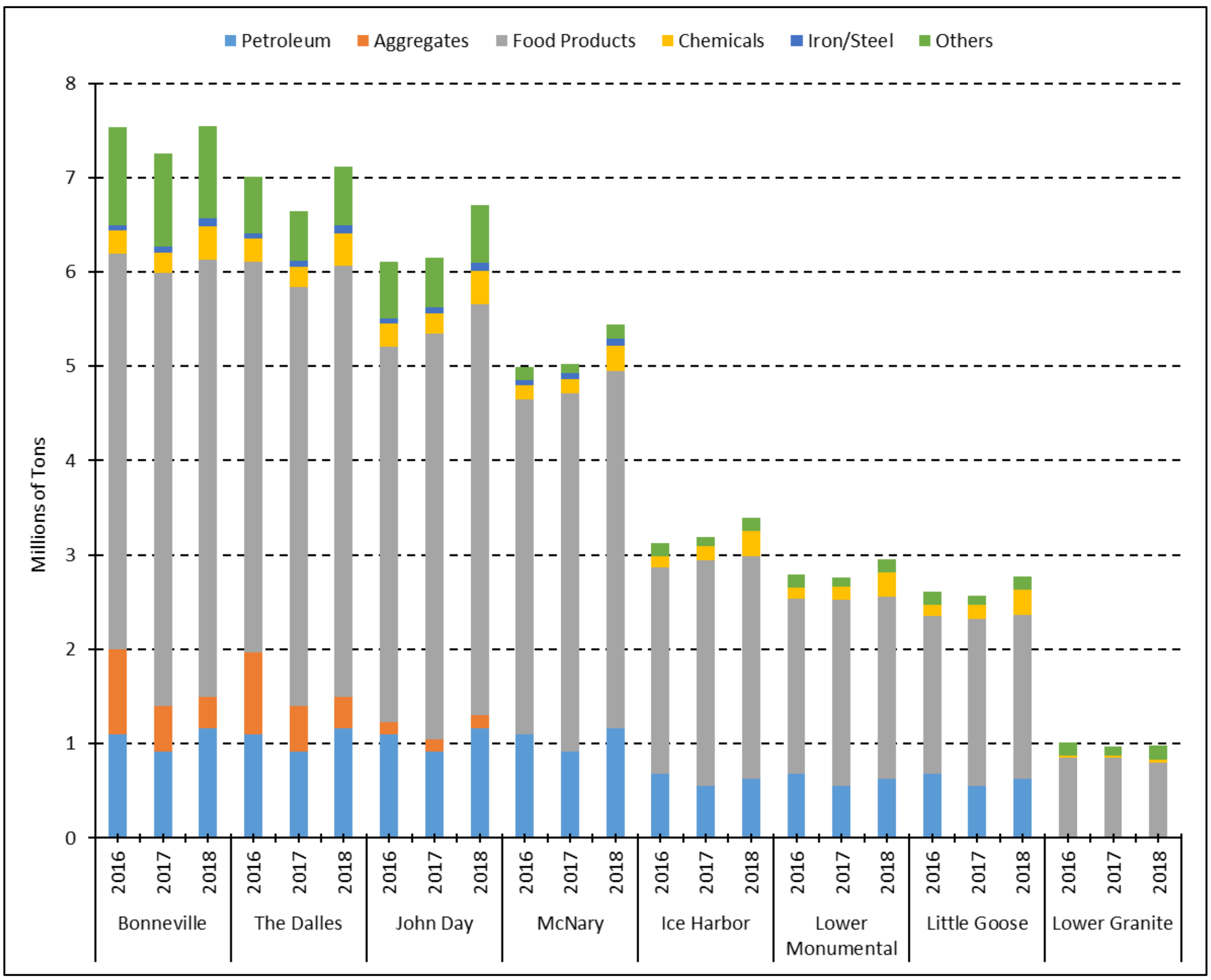
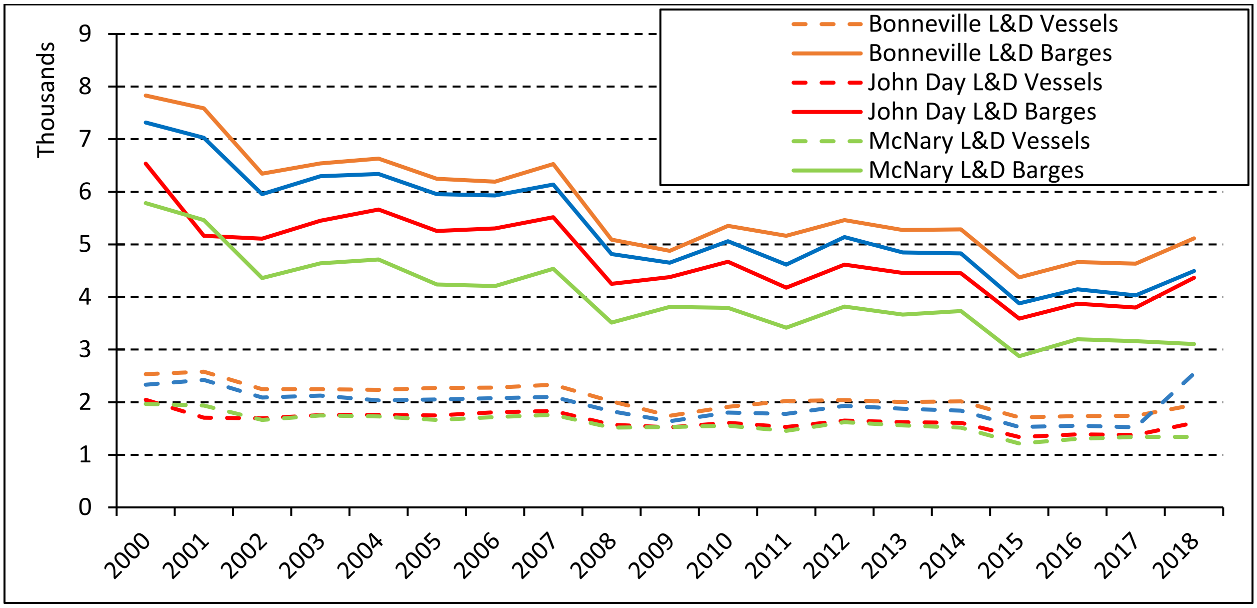



**Figure 3-204. CSNS Lock Freight Volumes by Commodity Group, 2016 to 2018**

Source: Corps Lock Performance Monitoring System (2020)

## VESSEL INFORMATION

Since 2000, barge traffic through locks at the CSNS has trended downward, while vessel traffic remained relatively stable. This suggests that the number of barges per vessel has declined over the past 18 years (Figure 3-205 and Figure 3-206, Corps Waterborne Commerce Statistics [2018]). Much of this is driven by changing export grain patterns for wheat in particular, competition between North American ports and transportation modes, and ocean freight rates.



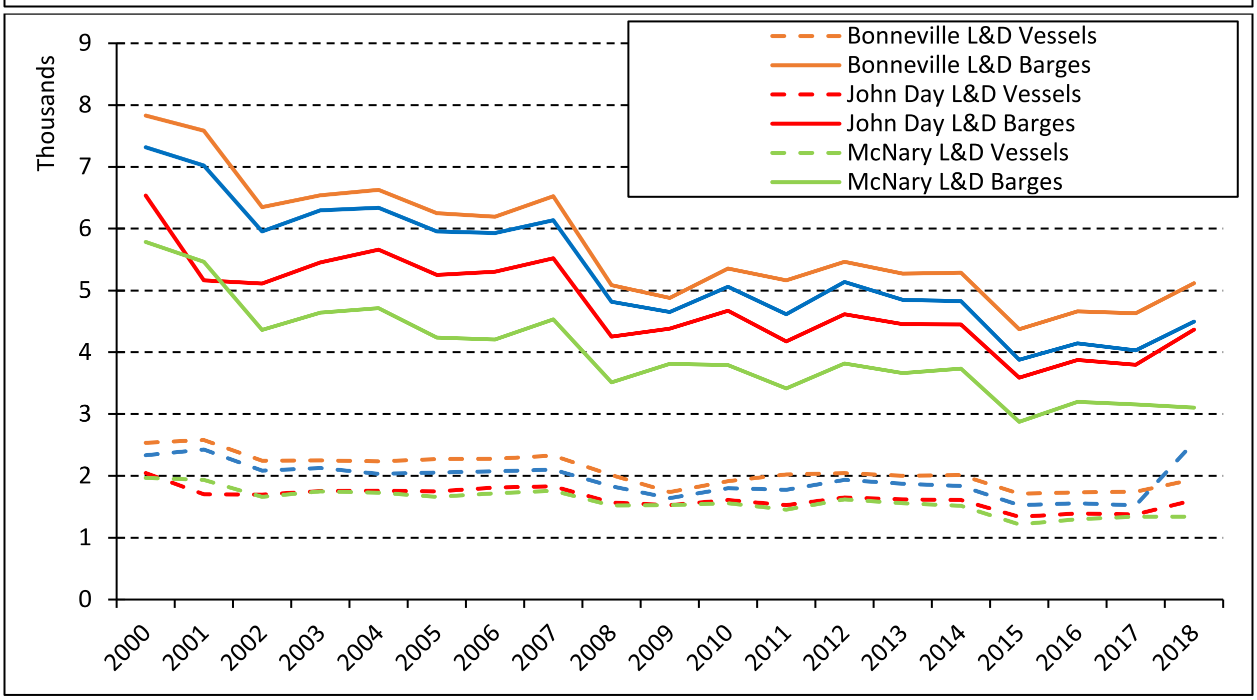
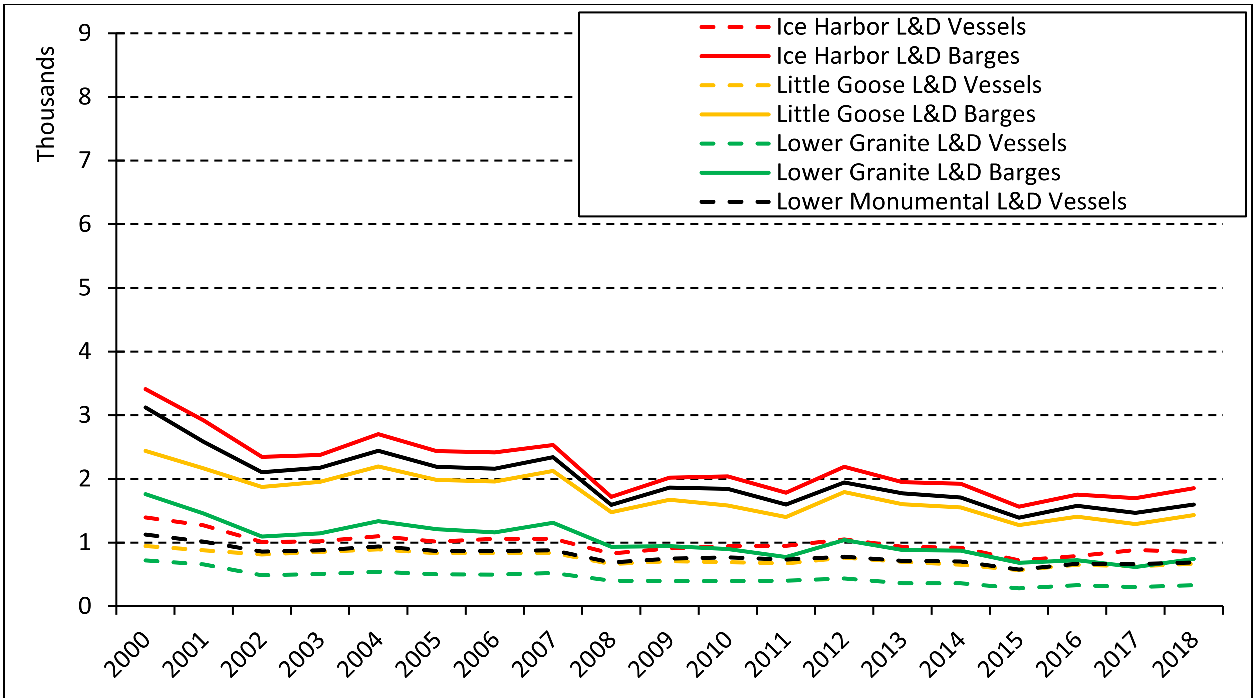




**Figure 3-205. CSNS Columbia River Lock Traffic, Number of Vessels Trips and Barges (2000 to 2018)**

Source: Corps Lock Performance Monitoring System (2020)



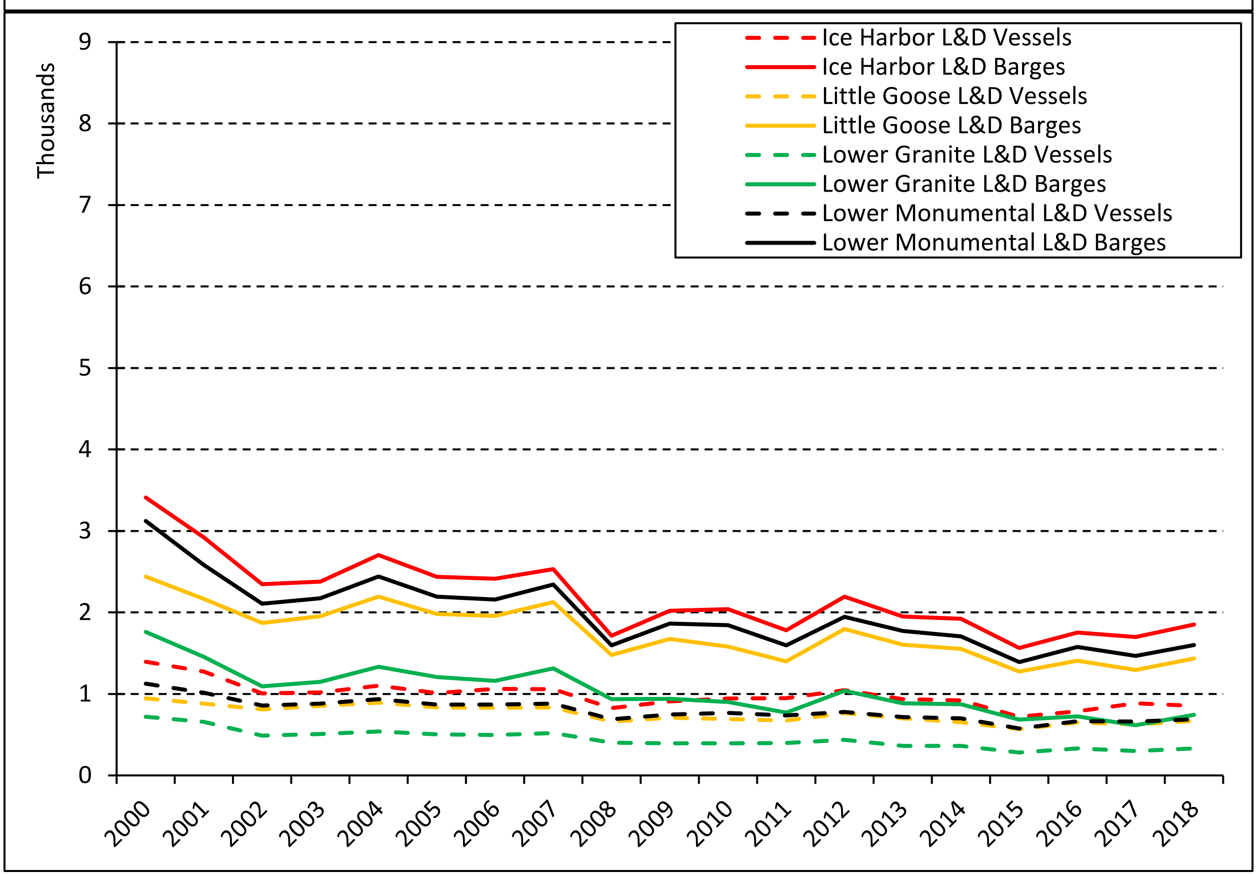




**Figure 3-206. CSNS Snake River Lock Traffic, Number of Vessels and Barges (2000 to 2018)**

Source: Corps Lock Performance Monitoring System (2020)

### Deep-Draft Navigation Channel

Table 3-230. summarizes vessel calls, which are ship dockings at ports, on the CSNS by draft and vessel type in 2016. Bulk carriers accounted for 75 percent of the deep-draft vessel calls on the CSNS in 2016. Vessels with a draft of 39 feet or less account for 82 percent of all vessel calls, and approximately 13 percent of the vessel calls in 2016 had drafts of 42 feet or 43 feet. While the channel is 43 feet and vessels need 2 feet of under-keel clearance, the movements drafting 42 feet and 43 feet likely occurred when water levels were slightly higher. No vessels moved with a draft over 43 feet (Corps Waterborne Commerce Statistics 2018). Bulk carriers account for the great majority of deep-draft vessels maximizing the use of channel depth (Figure 3-3-207).

**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% |

Source: Corps Waterborne Commerce Statistics (2018)

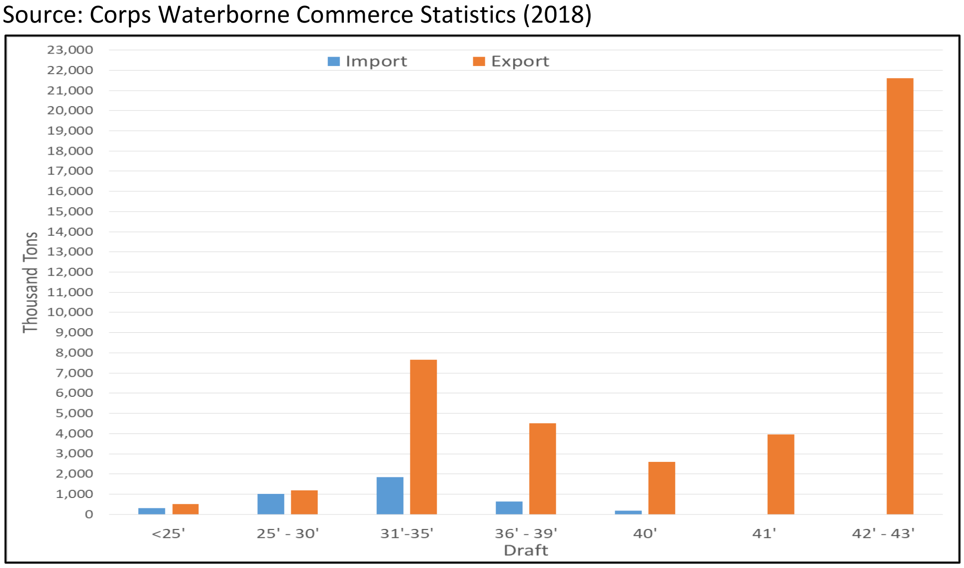



**Figure 3-207. CSNS Imports and Exports by Vessel Draft, 2016**

Source: Corps Waterborne Commerce Statistics (2018)

The largest deep-draft vessels are container ships, petroleum tankers, and tank barges. Both tankers and tank barges can be nearly 1,000 feet long. Tank barges are pushed by oceangoing tugs that notch into the barge. This trade is confined to the Pacific Coast, primarily out of refineries in California and Washington. Container vessels moving on the CSNS can be nearly 1,000 feet long. The ocean trade, though, is dominated by bulk vessels in the Handysize and Handymax class. These vessels are generally in 490 to 655 feet long, have onboard cranes, and capacities from 15,000 to 60,000 tons (Corps Waterborne Commerce Statistics 2018). These features make them ideal for serving Pacific Rim ports with limited draft and infrastructure. Bulk carriers in these classes accounted for 75 percent of dry bulk carrier vessel calls on the CSNS ( Table 3-230.).

**Shallow-Draft Navigation Channel**

In 2016, dry cargo barges accounted for 60 percent of the barge fleet on the CSNS (Table 3-231.). The preponderance of covered dry cargo barges reflects the importance of wheat in the mix of commodities moving on the inland/shallow-draft system. Deck barges (often used to move containerized cargo) account for another 21 percent of all non-self-propelled vessels, followed by tank barges used to carry petroleum products and liquid chemicals. Though not all barges are used in the canalized portion of the CSNS above Bonneville Lock and Dam, all but 5 of the 172 barges in the 2016 fleet were capable of moving through the 86-foot-wide lock chambers. The largest barges were dominated by tank barges (17 of the 30 large barges). In the next largest category, the 251-foot to 300-foot length group, covered hopper barges dominated and accounted for over 54 percent of all covered dry cargo barges. Barges in the fleet do not necessarily move through the locks as many are used in the coastal trade between California, Oregon, Washington, and Canadian Pacific coast ports.

**Table 3-231. Inland Non-Self-Propelled Vessel (Barge) Fleet**

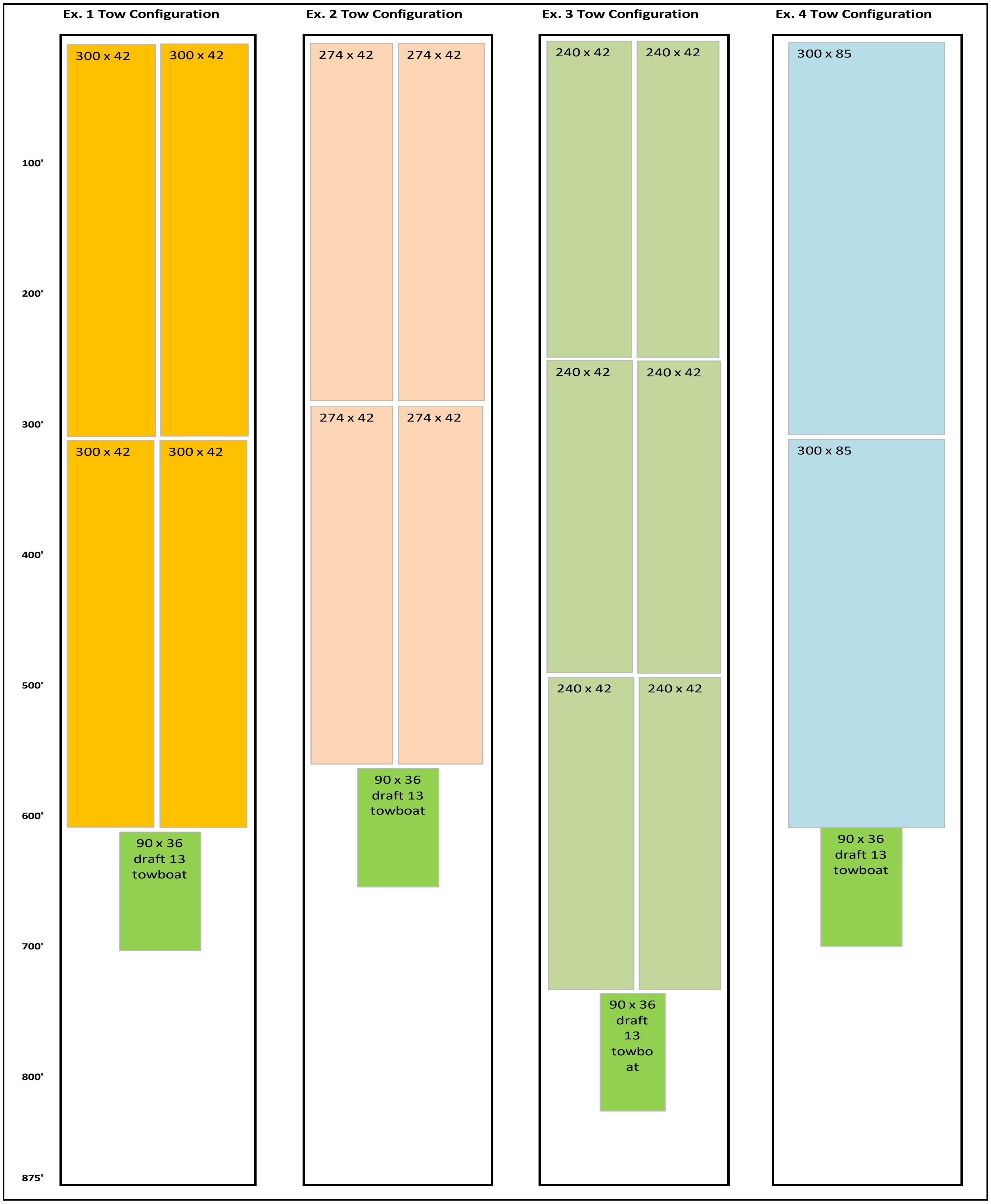
| LENGTH (ft) | WIDTH (ft) | DRAFT (ft) | BARGE TYPES | | | | | TOTAL |
|---|---|---|---|---|---|---|---|---|
| | | | Deck | Tanker | Open Dry Cargo | Covered Dry Cargo | Other | |
| 130-200 | 30-42 | 13-15 | 0 | 0 | 1 | 0 | 0 | **1** |
| 130-200 | 30-42 | 7-12 | 12 | 0 | 3 | 0 | 0 | **15** |
| 130-200 | 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% | |

Source: Corps Waterborne Commerce Statistics (2018)

Figure 3-208 shows possible tow configurations for four of the more common barge types in the system. As can be seen in the figure, most barge sizes in a four-barge tow configuration can be comfortably accommodated in CSNS lock chambers. While the 240-foot × 42-foot barges could be configured in four-barge tows, few barges of this size are available to vessel operators on the CSNS. It should be noted that tows do not necessarily move in configurations using barges of the same dimension.

Traffic has held fairly steady between 2012 and 2018 at CSNS locks. Tonnages generally build moving downstream, ranging from a 7-year average low of 1.1 million tons at Lower Granite Dam to a high of 8.0 million tons at lowermost Bonneville Dam (Table 3-232.). In 2018, 1,948 tows pushing 5,118 barges moved traffic through Bonneville Dam, while 333 tows pushing 724 barges moved Lower Granite tonnage. Also in 2018, the average tow sizes for CSNS locks ranged between 2.0 barges per tow at Lower Granite and 2.69 barges per tow at The Dalles Dam. Depending upon the lock, barges used on the CSNS carried between 2,791 tons and 4,458 tons on average between 2012 and 2018. The average tons per tow ranged from 2,633 tons to 6,094 tons during this time period.

32035 


32036 **Figure 3-208. Tow Configurations that Maximize Chamber Dimensions**

32037 Source: Corps Planning Center of Expertise for Inland Navigation (2018)

**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 |
| **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 |

| 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 |

Sources: Corps Waterborne Commerce Statistics (2020); Corps Lock Performance Monitoring System (2020)

### RAIL AND HIGHWAY TRANSPORTATION

Railroads and highways provide alternative modes of commodity transport within the Columbia River Basin. The recent decline in downriver barge freight on the Snake River, primarily in wheat exports, has coincided with investments in shuttle rail facilities in the Palouse region of Eastern Washington. Since 2002, four shuttle grain (rail) facilities have been built in Eastern Washington, including:

- Templin Terminal, Ritzville, Washington (2002)
- McCoy Grain Terminal, Rosalia, Washington (2013)
- Highline Grain, Four Lakes, Washington (2015)
- Northwest Grain Growers, Endicott, Washington (2019)

Trucks are also used for commodity transport, particularly for the movement of petroleum and chemical products to inland destinations. Trucks are also used in conjunction with other modes of transportation. For example, a significant portion of wheat and barley is harvested in eastern

Washington and transported by truck to Lower Snake River ports. At these ports, wheat and barley shipments are transferred to barge and transported down river. The highway network serving the study area includes Federal, state, and county highways. The majority of the links in the network serve low traffic volumes.

### DREDGING OPERATIONS

The Corps maintains the congressionally authorized depths of the Federal navigation channel throughout the Columbia River system. The ports and ship operators that use the CSNS depend upon the availability of the authorized depths to provide uninterrupted transit of fully loaded vessels. Dredging operations occur on a regular basis to maintain the deep-draft navigation channel while dredging is less frequent on the shallow-draft channel on the lower Columbia and lower Snake Rivers. Additional details are provided by navigation channel type below.

#### Deep-Draft Navigation Channel

The deep-draft system exists from the mouth of the Columbia River at RM 0, to the Portland, Oregon-Vancouver, WA area at RM 106. The dredging of the lower Columbia River, what is now the deep-draft channel, began in 1878, when a 20-foot channel depth was authorized by Congress. Over the years, the authorized channel depth and width has been increased by Congress multiple times. In 1892 a 25-foot channel was authorized and in 1912, Congress authorized a 30-foot channel and designated that the channel should be 300 feet wide. In 1930, Congress authorized a 35-foot channel. In 1962 Congress authorized the deepening and widening of the channel to a condition similar to current day – the authorized channel became 600 feet wide and 40 feet deep. And in 1999, Congress authorized the current deep-draft channel depth of 43 feet.

In order to maintain the current 600-foot width and 43-foot depth of the Columbia River deep-draft navigation channel, extensive dredging of the channel is required. The amount of sediment that accumulates in the channel is affected by the speed of the river flow. Generally, the faster the river flows (measured in cfs), the more sediment will build up in the navigation channel. Dredging of the deep-draft section of the Columbia River is typically completed by one of three Corps vessels, and in some instances, contracted dredges. On average, 6 to 7 MCY (million cubic yards) of sediment is dredged annually to maintain the Columbia deep-draft navigation channel.

#### Shallow-Draft Navigation Channel

The shallow-draft portion of the Columbia and Snake Rivers extends from the Vancouver, WA at Columbia River RM 106 upstream to Lewiston, Idaho, at Snake River RM 143. The portion of the river from about RM 106 on the Columbia to The Dalles Dam is authorized to 27 feet deep and 300 feet wide but is maintained to 17 feet of depth up to Bonneville Dam and 14 feet of depth between Bonneville Dam and The Dalles Dam. The portion of navigable waterway above The Dalles Dam to Lewiston is congressionally authorized to be 14 feet deep and 250 feet wide.

Maintenance dredging on the lower Snake River for navigation purposes began in the 1970s, and channel maintenance continues in accordance with the Corps' 2014 Programmatic Sediment Management Plan (PSMP). The PSMP provides a framework to evaluate and implement long-term potential sediment management and reduction measures to address problem sediment areas. The PSMP also provides for interim management measures and dredging and dredged-material management for areas where sediment has accumulated to a point where it is interfering with safe navigation. The most recent maintenance dredging and disposal action under the PSMP occurred in early 2015, based on the identification of a need to address sediment accumulation that was interfering with commercial navigation. Prior to adoption of the PSMP, the last dredging operation occurred in the winter of 2005-2006. The approximate 9-year gap in dredging operations is longer than the historic average, as the Corps has historically addressed problem sediment that interfered with project purposes areas every 3 to 5 years. The longer period between the most recent maintenance actions was due primarily to a 2005 Settlement Agreement intended to resolve litigation over the Corps draft 2002 Dredged Material Management Plan, which led to study and preparation of the PSMP. Based on studies associated with the PSMP and historical data, it is anticipated that the majority of problem sediment management activities will continue to occur within Lower Granite Reservoir at the confluence of the Snake and Clearwater Rivers.

The 2005–2006 dredging activities removed approximately 336,000 cubic yards of sediment from the lower Snake River. The dredging performed under the 2015-2016 PSMP study removed 372,603 cubic yards of sediment. The main areas of sediment buildup occur at the confluence of the Snake and Clearwater Rivers near the Port of Clarkston, Washington, as well as at the Port of Lewiston at the confluence with the Clearwater River.

#### *3.10.2.2 Cruise Line Operations and Other Recreational Use of Navigation Channel and Locks*

As of 2019, seven river cruise ships have dedicated Columbia-Snake River itineraries (Macuk 2019). Approximately 18,000 passengers cruise along the river annually (Pacific Northwest Waterways Association 2017). Passenger ridership primarily occurs between April and November on lower Snake River cruise lines, and ridership has been growing in recent years. One cruise company reported that it more than doubled its passenger capacity on the CSNS in 2016 when it added a new vessel (Cruise Industry News 2015); it then introduced another large river cruise ship in 2018 (Macuk 2019). In 2018, the Columbia River outsold the Mississippi River for the first time, and all six operating cruise ships reported being sold out between May to October (Macuk 2019). One cruise company more than doubled its passenger capacity on the Columbia-Snake in 2016 with a new ship (Cruise Industry News 2015), and then introduced another large river cruise ship in 2018 (Macuk 2019).

Commercial cruise ships on the Columbia and Snake Rivers typically cruise between Clarkston, Washington, and Astoria, Oregon, on the Pacific coast, with embarkation or disembarkation in Portland, depending on which direction the ship is traveling. Most of the cruises are seven nights with the option of a pre- or post-stay in Portland. Along the way, the ships traverse eight locks (Uzelac 2018). A standard itinerary might would involve stopping at (1) Portland, Oregon;

(2) Astoria, Oregon; (3) Mount St. Helens, Washington; (4) Stevenson, Washington; (5) The Dalles, Oregon; (6) Pendleton, Oregon, or Richland, Washington; and (7) Clarkston, Washington (ACL 2019). Clarkston, Washington, is located in Region C and the other six ports of call are located in Region D.

On the industry side, cruise boat operators make a range of payments. They pay fees associated with the use of a port, and purchase food and other perishable items. Operators also purchase necessary goods and services for the vessels, such as fuel, waste disposal, line handling, and local pilots. Cruise lines may also hire local entertainers and tour guides as part of their services (Macuk 2019).

The navigation channel and locks of the CSNS are used not only by large, commercial vessels, but also by smaller, recreational vessels (Figure 3-209). When recreational boaters wish to move upstream or downstream past one of the CRS dams, their vessel must first be determined suitable to lock through. To maintain safety as a priority, non-motorized vessels and those deemed not suitable for safe passage through the navigation locks are advised to be transported by land around the dams. For those recreational vessels suitable for lockage, the Corps' Portland District and Walla Walla District post instructions for safe lockage on their respective websites. The CSNS navigation locks offer a seasonal recreation-priority lock use, which runs typically from mid-May through mid-September each year. Even during recreation-priority season, vessel operators must request permission to lock through from the lock operator to allow for confirmation that the conditions are safe. For the remainder of the calendar year, recreational vessel lockage is made available during daylight hours only and after requesting permission ahead of arrival. The CSNS navigation locks are closed to all river traffic annually in March for approximately 2 weeks to conduct routine maintenance.



32153
32154 **Figure 3-209. Vessels in Navigation Lock**
32155 Source: Corps' PAO Office, Portland District 2019

#### *3.10.2.3 Ferry Transportation*

The Confederated Tribes of the Colville Reservation (CTCR) operates a free ferry, the Columbia Princess, between Inchelium and Gifford, Washington, on Lake Roosevelt on the eastern side of the reservation. In 2018, a total of 150,000 passengers rode the Inchelium-Gifford ferry, which is equivalent to approximately 410 passengers per day on average (CTCR 2019). The 2018 data suggests that most of the travel is by individual passengers, many of whom traveled in some of the 87,000 cars on trips across the river, as well as buses, trucks, and bicycles. Travel occurs throughout the year, but peaks in summer months. People who live in rural towns near Inchelium on the Colville Reservation describe the ferry as a “lifeline” (KHQ 2014). The ferry is important to commuters, schoolchildren, emergency services, tourists, and the tribe as a whole (CTCR 2019; FHWA 2017; KHQ 2014). When the ferry does not operate, schoolchildren living in the areas must be bussed on a 70-mile detour to the nearest bridge and people who need medical attention face an hour and a half drive instead of a free, six-minute ferry ride to reach the community health care clinic (KHQ 2014). The Tribe also reports that the ferry is important for transport of gas, food, and supplies (CTCR 2019). Although the Tribe has requested that a bridge be built to replace the ferry, this project has not been planned. The ferry closes in above-average water conditions (typically during the spring) when water levels do not permit the ferry to operate. The docks only allow the ferry to operate when reservoir elevations are higher than 1,229 feet above sea level (NAVGD29). In 2018, the ferry was shut down 20 days during April and May because the water level was too low (CTCR 2019). When the water level falls below this level, the ferry has to halt operations until water levels rise (CTCR 2019).

The Washington Department of Transportation operates the Keller Ferry, which also operates on Lake Roosevelt. Approximately 60,000 vehicles travel on the Keller Ferry each year. The free ferry operates 7 days a week, 18 hours a day, and can operate normally with lake levels as low as 1,208 feet. During normal lake elevation of 1,290 feet above sea level to approximately 1,248 feet, ferry service is "on-demand" to avoid unnecessary empty runs.

Wahkiakum Ferry has operated near Westport Slough on the lower Columbia River in Washington State since 1925. It operates 365 days a year, making at least 18 runs a day. The ferry is run by the Wahkiakum County Public Works Department and offers single-trip and frequent traveler rates to tourists and commuters (Wahkiakum Chamber of Commerce 2019).

### 3.10.3 Environmental Consequences

The MOs include actions with the potential to affect reservoir elevations, river flows and stages, sedimentation patterns, as well as system configuration (e.g., under MO3, due to breaching of four lower Snake River dams, the Snake River shallow-draft reach is assumed to be inoperable). These physical changes in reservoir and river conditions could potentially affect commercial navigation activities, commercial ferry operations and/or commercial cruise ship operations, as well as access to the navigation channel from existing port and/or dock facilities. Depending on the effects to the navigation channel and adjacent facilities, additional maintenance or dredging may be required. Changes to the CSNS will influence the cost of transporting goods in the region and may affect the accessibility of the system for use by ferries and cruise ships.

Changes in transportation costs and accessibility will affect social welfare values and regional spending patterns, and may also result in other social effects. This section describes effects to commercial navigation and transportation from changes in river flows, depths, and configuration that may result from the MOs.

#### *3.10.3.1 Methodology*

The analysis assesses effects of the MOs associated with changes to commercial navigation activities, commercial cruise line operations, ferry operations, and related transportation system (e.g., road and/or railway) effects as compared to the No Action Alternative. Effects to dredging activities are also described. The analysis begins by establishing the baseline conditions that would be anticipated under the No Action Alternative. For each activity, the analysis then assesses potential effects of MOs on social welfare (i.e., national economic development), regional economic spending patterns, as well as other social effects:

Social welfare effects are changes to the economic value of the national output of goods and services. The economic value includes producer surplus gained from commercial navigation activities, as well as the value, or the improved well-being, gleaned by tourists and recreationists associated with cruise line visits (referred to by economists as consumer surplus or net economic value). For this analysis, effects to commercial navigation activities are measured in terms of changes in transportation costs. The model itself does not address transitional costs associated with short-term infrastructure investments that may be required. Transitional costs are the short-term, one-time infrastructure investment costs that would be required to add capacity to remaining alternate transportation modes. Specifically for this analysis, transitional costs would include investments in road, highway, adding and/or upgrading rail (both short line and Class 1), as well as adding storage capacity at shuttle rail facilities and grain elevators.

The following are included as part of the regional economic effects discussion.

- Regional economic effects are changes in the distribution of regional economic activity (e.g., income and jobs), which is affected by changes in expenditures. Because the pattern of freight transportation may change in the Columbia River Basin under different alternatives, so too might the distribution of regional economic activity. The regional economic effects are distinct from the national social welfare effects in that they relate to effects mainly to the localized or regional economic area, instead of the nation as a whole. For MOs that involve modal changes, transitional costs may be associated with infrastructure investments, particularly highways, bridges, and rails that may be required and are also reported under regional economic effects. Over the long term, price increases on the primarily private rail system should adjust to cover these costs, but may not in the short term. Highway maintenance cost increases may be covered by public investments. Additional regional effects may be associated with changes in cruise line or ferry operations and are reported as regional economic effects.

- Other social effects are community and social effects that are relevant to various MOs, but are not addressed under social welfare or regional economic effects. Additionally, air emissions could increase or decrease with different transportation modes in place. For MOs where commercial navigation freight is shifted to other transportation modes, like trucks, effects to air emissions would increase. Other effects that are not dependent on modal changes may include impacts to community well-being, identity, and cohesion. Section 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal Interests*, provides additional information about ongoing effects and unique effects of MOs on tribal ceremonial activities, subsistence activities, and other cultural practices.

Impacts to Canadian transportation systems are not anticipated under any MOs and are not addressed further in this analysis.

**SOCIAL WELFARE EFFECTS**

**Commercial Navigation and Transportation Systems**

Businesses that transport bulk commodities in the Interior Northwest often pay lower transportation costs than parties transporting commodities via land transportation (GAO 2011). These inland navigation benefits are often referred to as "transportation rate savings." Transportation rate savings are the difference between the cost of transporting commodities over the waterway and the next least cost alternative mode of transportation, typically rail or roadway. These transportation rate savings provide an estimate of changes in social welfare associated with an alternative.

This analysis uses two models to evaluate the effects of changes to social welfare. The Snake Columbia Economic Navigation Tool (SCENT) is a model that calculates changes in transportation costs attributable to changes in flows and/or navigation channel depths on the commercially navigable portions of the Columbia and Snake Rivers. For MO3, where navigation is expected to be eliminated for a portion of the CSNS, the Transportation Optimization Model (TOM) is used in addition to the SCENT. The TOM is used to assess the flow of shipments under a dam breach scenario where navigation on the lower Snake River is eliminated.

Summary information is provided about the models in the sections that follow; more detailed information about the models, data inputs, and results is provided in Appendix L, *Navigation*.

***Modeling Changes to River Flow and Timing***

The SCENT model is used to estimate changes in transportation costs for alternatives that may affect flow and/or navigation channel depth. The model also accounts for changes in the timing of operations. The SCENT model is used to evaluate effects for MO1, MO2, and MO4. It is also used to evaluate effects for the Columbia River deep-draft and shallow-draft portions of MO3. The SCENT requires the following inputs:

- Daily flows in cfs and daily water surface elevations, which have been developed as part of the H&H analysis as an output from the ResSim model. The ResSim model sampled 80 years of historical river data to create 5,000 years of daily flows and water surface elevations, which were fed into the SCENT model.

- Data on the number and types of waterway vessels, including, barges and towboats using the CSNS provide by the Corps Lock Performance Monitoring System (LPMS) for 2016.[2]
- Data on the costs for operating waterway vessels provided by the Corps' Institute for Water Resources Waterborne Commerce Statistical Center (2016 costs updated to 2019 dollars).
- Origin, destination, commodity volumes, and type for all movements (i.e., river origin to river destination) traveling on the CSNS for a given year. For this analysis, 2016 movements are used. The CSNS characteristics in 2016 were chosen because the SCENT model requires a list of movements to estimate the effects to navigation. The list of movements is generated by combining several sources of data including the Corps' Waterborne Commerce Statistics (WCS), LPMS, Port Import and Exporting Reporting Service (PIERS), and other sources. All datasets were available for 2016.[3]
- Survey responses indicating movement decisions of operators to various flow, stage, depth, and velocity thresholds (documented in 2016). The responses of industry to this survey are reflected in the modeling assumptions described in this section.

The SCENT output is an estimate of navigation transportation costs under each alternative. A comparison in transportation costs between the No Action Alternative and the MOs determines the impact to waterway transportation costs under each MO. The SCENT calculates draft restrictions based on modeled water surface elevations and shoaling depths (between 37 and 42 feet).

SCENT results are calculated separately for the shallow-draft and deep-draft portions of the CSNS. Shallow draft is broken down into three subcategories, for a total of four industry segments:

- **Deep Draft** pertains to the Columbia River below Bonneville Dam
- **Snake Shallow** refers to movements that originate and terminate on the lower Snake River[4]
- **Columbia Shallow** refers to movements that originate and terminate on the Columbia River, above Portland, Oregon
- **Columbia-Snake Shallow** refers to movements that originate on the lower Snake and 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.

River flows can affect the operating costs for navigators on the river. Low river flows as well as particularly high river flows result in increased costs for commercial navigation activities when compared with normal flow conditions. Low flow and high flow conditions may result in a need for changes in tow configuration and/or changes in loading or the number of barge trips required. For deep-draft vessels, channel depth changes that cause draft restrictions affect operating costs by requiring light loading or other adjustments to account for limitations in channel depth. Based on the survey responses described above, normal, low, high, very high, and too high flow conditions for navigation operations on the CSNS were identified. These flow rate categories and associated flow ranges are presented in Table 3-233.. The SCENT model is used to estimate the additional costs for commercial navigation activities of operations in other than normal flow conditions in these years.

**Table 3-233. Flow Range Categories for Commercial Navigation on the Columbia-Snake 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 |

In order to help account for normal variability, a standard deviation[5] was calculated to determine the range of costs that would be anticipated to fall within one standard deviation of the deep-draft and shallow-draft flow categories and the deep-draft restrictions under the No Action Alternative. For each of the MOs, the standard deviation range was then used to highlight those changes in costs that would be outside of one standard deviation of the current (No Action) condition.

***Modeling Effects of Changes in Channel Accessibility***

The TOM is used to assess the movements of shipments under a dam breach scenario where navigation on the lower Snake River would be eliminated. Under MO3, it is assumed that a portion of the navigation channel would be inoperable, therefore affected shippers would be required to use a different transportation mode or combination of modes (e.g., shuttle rail, connector rail, roadway, Columbia River shallow- and/or deep-draft channel). Therefore, the TOM is used to evaluate the flow of goods from origin points, through intermediate destinations, and ultimately to final destinations.

The TOM is a constrained optimization model designed to simulate the transportation choices facing shippers that use the CSNS. The TOM focuses on goods that are shipped in the region surrounding the lower Snake River shallow-draft portion of the CSNS, recognizing that the lower 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.

fuel upriver. There are other commodities moved in smaller volumes, but wheat comprises more than 87 percent of the tonnage moved on the lower Snake River. Therefore, the TOM is designed to capture the choices faced by shippers moving grain to market.

Information gathered through a survey of shippers conducted as part of this EIS was used as a framework for the model to evaluate how goods would move through the system if the lower Snake River navigation channel is made inoperable.[6] Model parameters include the capacities of each facility, shipping alternatives, cost of each shipping alternative, choices made under the No Action Alternative, and choices that would be made if the navigation channel was unavailable. The model is sensitive to price assumptions, which affect the modal choices. For the social welfare analysis, the relevant output of the TOM is the change in cost of grain movements affected by lower Snake River navigation being eliminated.[7] As discussed above, grain (wheat and barley) comprises approximately 87 percent of downriver-bound shipments on the lower Snake River.

***Modeling Effects to Dredging and Maintenance Activities***

Changes to sedimentation patterns in the CSNS system have the potential to impede commercial navigation activities and/or may result in increased need for dredging activities in some areas. Increased dredging activities would increase dredging costs. While qualitative analysis was conducted to describe the impacts to dredging activities from MO1, MO2, and MO4, the *Breach Snake Embankments* measure require a quantitative estimate.

Potential effects to dredging activities were evaluated for each alternative based upon the River Mechanics results (see River Mechanics Section 3.3.3), along with input from District operations and cost engineering experts. Potential changes to dredging costs were estimated using the following steps:

- Step 1: Estimate the potential amount of additional sediment from an operational or structural *measure(s). For example, the Breach Snake Embankments* measure would lead to an increase in sediment within the McNary Pool for several years after breeching (see Section 3.10.3.5, *Dredging Operations*).
- Step 2: Based upon the capacity of the channel, flows, and other information, identify the likely areas within lower Snake and lower Columbia River for increased sedimentation.
- Step 3: Estimate likely dredging volumes and schedule for key areas such as the Federal 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.

- Step 4: Develop a per-cost estimate for dredging to estimate the total cost for dredging activities, depending upon the dredging location.

By comparing the estimated dredging cost to the No Action Alternative, the analysis developed an estimate for the impact in dredging cost by MO.

**Commercial Cruise Line Operations**

Under MO1, MO2, and MO4, potential effects to commercial cruise lines are estimated using estimates of changes in the number of low and high flow days generated with the SCENT model. Under MO3, commercial cruise line access to the lower Snake River would be eliminated and the analysis estimates the number of cruise line trips that would be precluded. Substitution of trips is assumed to be not possible within the region.

**Commercial Ferry Operations**

This analysis focuses on the Inchelium-Gifford Ferry on Lake Roosevelt in Region B because elevation changes from the MOs may affect its operations in some years. Two additional ferries, the Keller Ferry on Lake Roosevelt in Region B, and the Wahkiakum Ferry, located near Westport, Oregon, in Region D, are not anticipated to be affected by elevation changes or changes to flow conditions under any alternative and are not addressed in further detail.

Under each alternative, anticipated daily reservoir water surface elevations in Lake Roosevelt are evaluated at ferry port locations to determine whether ferries could operate. The analysis uses H&H data for each alternative for dry, wet, and average water years at Lake Roosevelt (Grand Coulee Dam forebay elevation) and compares it to established minimum operating elevations for each ferry using daily elevation forecasts.[8] This comparison results in an estimate of the number of days annually that water levels would be at or above the minimum usable elevation for ferry operations. The minimum usable elevation for ferry operations of 1,229 feet NAVGD29 was identified through communications with ferry operators.

**REGIONAL ECONOMIC EFFECTS**

**Commercial Navigation and Transportation Systems**

The regional economic effects analysis of commercial navigation evaluates how potential changes to navigation and transportation costs (and associated activities) would impact regional economies. The analysis describes the port facilities in the CSNS, and how these ports would be affected by changes in the flows and/or navigation channel depths (or both) on the 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.

effects to port services, including navigation freight companies, that could result if navigation is eliminated under MO3. This evaluates potential regional economic effects associated with increased costs to the agriculture industry; increased demands for infrastructure, including highways, rail lines, and grain elevators; impacts to port facilities and barge companies; impacts to support industries for the commercial cruise lines; and other city and local implications.

The regional economic implications of changes in costs for transporting goods, whether that is in the current shipping channel or via other modes of transportation, are also evaluated. The industries shipping goods on the CSNS are the producers of the commodities (e.g., wheat producers), as well as purchasers of commodities (e.g., fuel). The regional economic impact analysis considers how any increases in costs for shipping commodities would affect the costs to producers of commodities, and how those changes would affect regional economies. This analysis assumes that increased costs of operations would result in decreased profitability of commodities being produced, and estimates this by assuming this loss would be reflected in lost revenues to those industries. This analysis evaluates the regional economic implications of these changes, including estimates of changes in local expenditures, sales, labor income, and employment.

**Commercial Cruise Line Operations**

Commercial cruise lines provide tourist dollars to the regional economies they visit. The regional economic analysis addresses potential effects to these expenditures of alternatives that are anticipated to affect access of commercial cruise lines to the lower Snake River. This analysis evaluates the regional economic implications of these changes, including estimates of changes in local expenditures, sales, labor income, and employment.

**Commercial Ferry Operations**

The regional economic importance of the ferries to these areas as well as the implications of changes to ferry service on the regional economies that they serve is described qualitatively.

**OTHER SOCIAL EFFECTS**

Other social effects are community and social effects that are relevant to various MOs but are not addressed under social welfare or regional economic effects. These may include effects to public health and safety, as well as community well-being, cohesion, or identity.

**Commercial Navigation and Transportation Systems**

Moving commodities on the waterway results in fewer air pollutant emissions compared to truck and rail transportation. Truck transportation can emit nearly 10 times more $CO_2$ per ton-mile than inland barges (Kruse, Warner, and Olson 2017; refer to Section 3.8, *Air Quality and Greenhouse Gas Emissions* for additional details). As such, any reductions in navigation service that result in transportation of goods via land-based modes would generally result in increased air pollutant emissions. Alternatives may result in increased costs of operations with or without modal changes, with the potential for changes in tow configuration and/or changes in loading and number of barge trips. This analysis assesses these effects by conducting an evaluation of changes in emissions using estimates developed in the social welfare analysis of the potential tonnage that could move off the water as well as using published emission factors for inland waterway vessels and trucks.

Changes in transportation modes can also have implications for public safety. For example, accident rates are generally higher for road travel than travel by either barge or rail (Inland Rivers Ports & Terminals, Inc. 2019). In addition, changes that result in increased truck usage would also add to vehicular traffic and congestion and may require additional road and highway infrastructure costs. Effects of changes in transportation modes on accident rates and congestion are discussed.

Under MO3, where the navigation channel on the Snake River would become inoperable, substantial changes to port operations would be anticipated. Changes could include wholesale change in land uses at the ports. Some ports may be able to adapt to land-based shipping demands, while others may not. These structural changes to the economic base would affect regional demand for some labor categories and could affect commuting patterns as well as housing demand. The loss or transition of port operations in some communities could also result in community-level effects associated with changes in the character of the communities and community identity. These effects are discussed qualitatively for MO3 (Section 3.10.3.5).

**Commercial Cruise Line Operations**

The analysis considers qualitatively whether changes in cruise line tourism could affect community identity.

**Commercial Ferry Operations**

This analysis evaluates how changes in ferry operations may affect communities that rely on ferries for access to services, including healthcare, emergency services, tourism, and schools.

### *3.10.3.2 No Action Alternative*

**SOCIAL WELFARE EFFECTS**

**Commercial Navigation and Transportation Systems**

As described in Section 3.10.2, *Affected Environment*, overall waterway traffic on the CSNS has been relatively stable over the past 20 years at an average of 54.1 million tons, with the deep-draft segment accounting for the majority of the total tonnage. Recent years have shown an increase in annual deep-draft movements, and some decline in annual shallow-draft movements that have corresponded to an increase in shuttle rail facilities built recently in the Palouse region. Industrial as well as agricultural production are projected to increase through 2050, which indicates that shipping demand will continue (NW Council 2019). A portion of this agricultural production increase may be transported on the lower Snake River channel. As discussed in Section 3.10.2, *Affected Environment*, key commodities moving on the CSNS are food and farm products (wheat, corn, and soybeans), which are being exported out of the region. Other important commodities moving on the CSNS in 2016 included fuel, chemicals, such as neutral sodium carbonate and fertilizers, and forest and paper products. Ongoing trends, in terms of type and volume of commodities, are anticipated to continue under the No Action Alternative. Transportation rate savings equals the savings associated with navigation as opposed to other transportation modes. The average transportation rate savings for shallow-draft traffic traveling on the Columbia and lower Willamette Rivers below Vancouver, Washington, in 2016 was estimated to be $266 million. The $266 million is determined by multiplying the per ton transportation rate savings from the Corps' Planning Center of Expertise for Inland Navigation and Risk Informed Economics Division (PCXIN-RED) database by the tons moving on the waterway. The PCXIN-RED transportation rate savings database contains estimates of transportation rate savings from the 2009 study: Transportation Rate Analysis for the Columbia-Snake Waterway System, which was prepared for Corps by North Dakota State University.

Table 3-234. presents the average commercial navigation flow days under the No Action Alternative for non-normal days. As indicated, most days would be expected to fall in the normal range under the No Action Alternative, and draft would typically exceed 43 feet.

**Table 3-234. Average Commercial Navigation Flow Days Under the 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)[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 |

1/ "Shallow" category applies to both the Columbia-Snake Shallow and the Columbia Shallow categories.
2/ Actual number of days for draft restrictions can be a function of the availability of funding and/or dredging equipment.
Source: SCENT modeling

Since 2016 is the base year for this analysis, then $266 million represents the benefit under the No Action Alternative for future years. Additional costs associated with extreme water flow conditions may reduce this benefit by $0.4 million to $5.5 million a year. Table 3-235. presents these average annual additional costs associated with non-normal flow conditions. As shown, while draft restrictions could occur for traffic with drafts ranging from 20 to 45 feet, the only vessels experiencing measurable restrictions under the No Action Alternative would be those with drafts of 37 through 42 feet.

**Table 3-235. Average Annual Costs of Navigation Operations Under a Range of Flow Scenarios, No Action Alternative (2019 Dollars), 50 years**

| | Costs Associated with Flow Range Categories (Non-Normal Flow Days) | | | | Costs Associated with Draft Restrictions (Non-Normal Flow Days) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **River Segment** | **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 |

Note: Costs of operations under normal flow range categories are not anticipated to be affected under any alternatives and are therefore excluded from the table. The “Columbia-Snake Shallow” category refers to traffic that travels on both the Columbia and Snake Rivers. The “Columbia Shallow” category refers to traffic only traveling the Columbia Shallow river segment. These are mutually exclusive categories.

The volume of grain that moves down the lower Snake River is assumed to be constrained to 2.4 million tons under the No Action Alternative. Figure 3-210 displays the volume of grain moving down the lower Snake River from 2000 to 2018 from the Waterborne Commerce data. The amount of grain moving by barge is a result of a combination of factors, including total production, which has been relatively stable over time, as well as market driven forces, including competition between and within transportation modes, which change from year to year. One of the market forces obviously are the market prices for grain, which are primarily determined internationally. The price point for grain at any one point in time may cause the growers and elevator managers to empty or fill their storage, leading to volume movements that vary from year to year. Further, some occasions have arisen in the market when it is more profitable for an elevator to sell railroad future car contracts for the secondary premium, moving grain to the river during that time. Additionally, over time the advent of new shuttle facilities has shaped the competitive geographical map in the region. As shown, the total grain volumes using the river have varied but generally declined since the early 2000s, with more precipitous declines since the opening of two additional shuttle rail facilities (McCoy and High Line Shuttle Terminals), followed by a decade of relative stable volumes of grain movements. In light of these historic trends the volume of grain shipped down the lower Snake River is assumed to remain constant over time, even as modest increases in grain production and technological improvements in yield are anticipated over time. As such, an estimate of 2.4 million tons was chosen to model future downbound grain shipments. The estimate of 2.4 million tons represents the 10-year average of downbound grain and barley shipments on the lower Snake River as well as the most recent data volume (2018) shipped in 2018, the latest year of reported data.

Table 3-236. summarizes specific assumptions about grain movements under the No Action Alternative, which were developed for the transportation optimization model, and then parameterized for the No Action Alternative. Figure 3-211 depicts shipping patterns by mode for grain shippers under the No Action Alternative. Specifically, the figure illustrates the highway flows of grain shipments, the location of origination points used in the transportation optimization model, river port terminals along the Columbia/Snake navigation channel (green circles) and shuttle rail terminals (orange dots). The intensity of highway flows is represented by thicker lines that change colors (moving toward dark red) as the volumes increase. The No Action Alternative illustrates the intensity of highways being used to move grain in the existing, base-case scenario and it shows thicker lines for highways connecting river port terminals and shuttle rail facilities. The size of the circles also reflects the increasing volume moving through each facility type (river port, shuttle rail, and elevator with rail) as grain is consolidated from farm to country elevators and on toward the tidewater terminals for export.

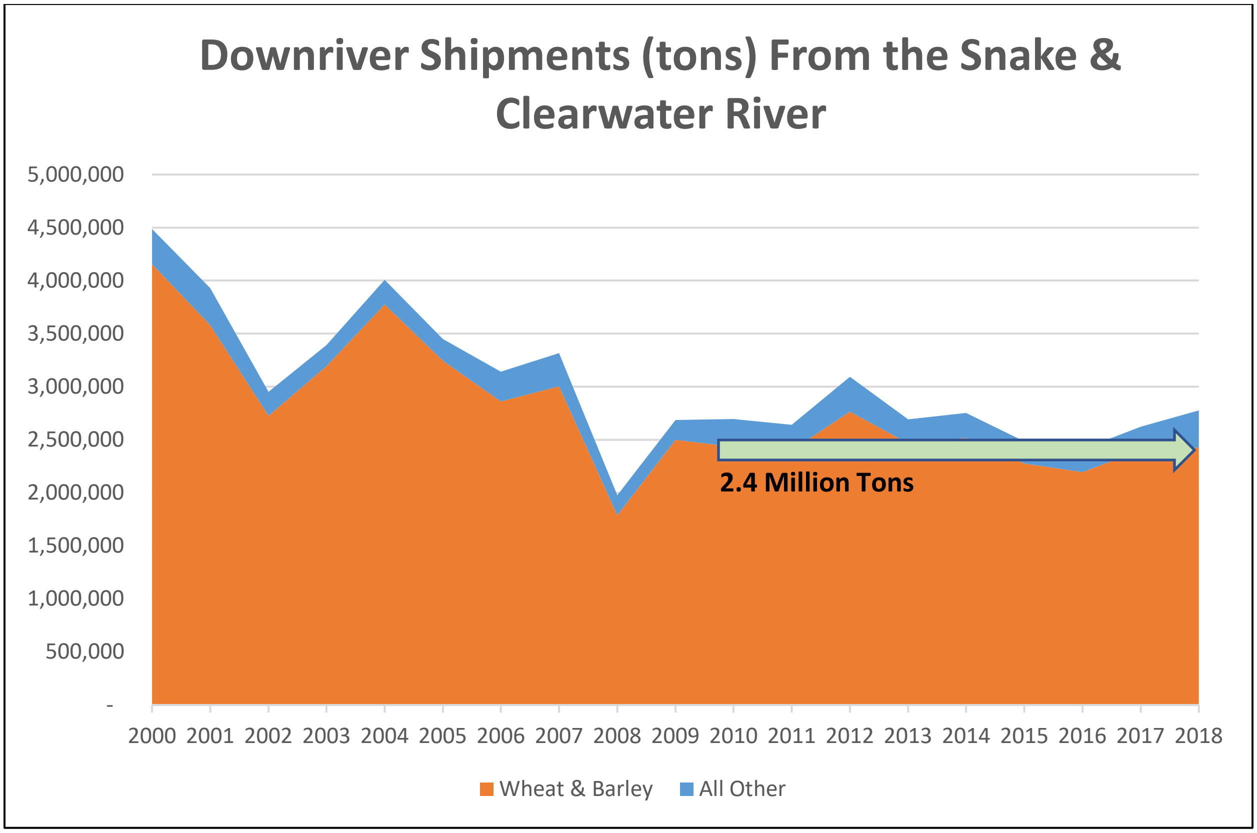



**Figure 3-210. Recent Grain Shipments on the Snake River, with No Action Alternative Forecast**

Note: Large decreases in grain tons during 2002 and 2008 are more reflective of exogenous factors and do not suggest an isolated effect from new unit train facilities. In 2002, there was a drought in eastern Washington that reduced grain supply. In 2008, the global recession influenced demand for grain.

Source: Corps Waterborne Commerce data (2018).

**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 | – |

Note: avg = average.
1/ Assumes 2.1 million tons of grain moving down the Snake River via barge.
Source: Transportation optimization model, parameterized to reflect current conditions

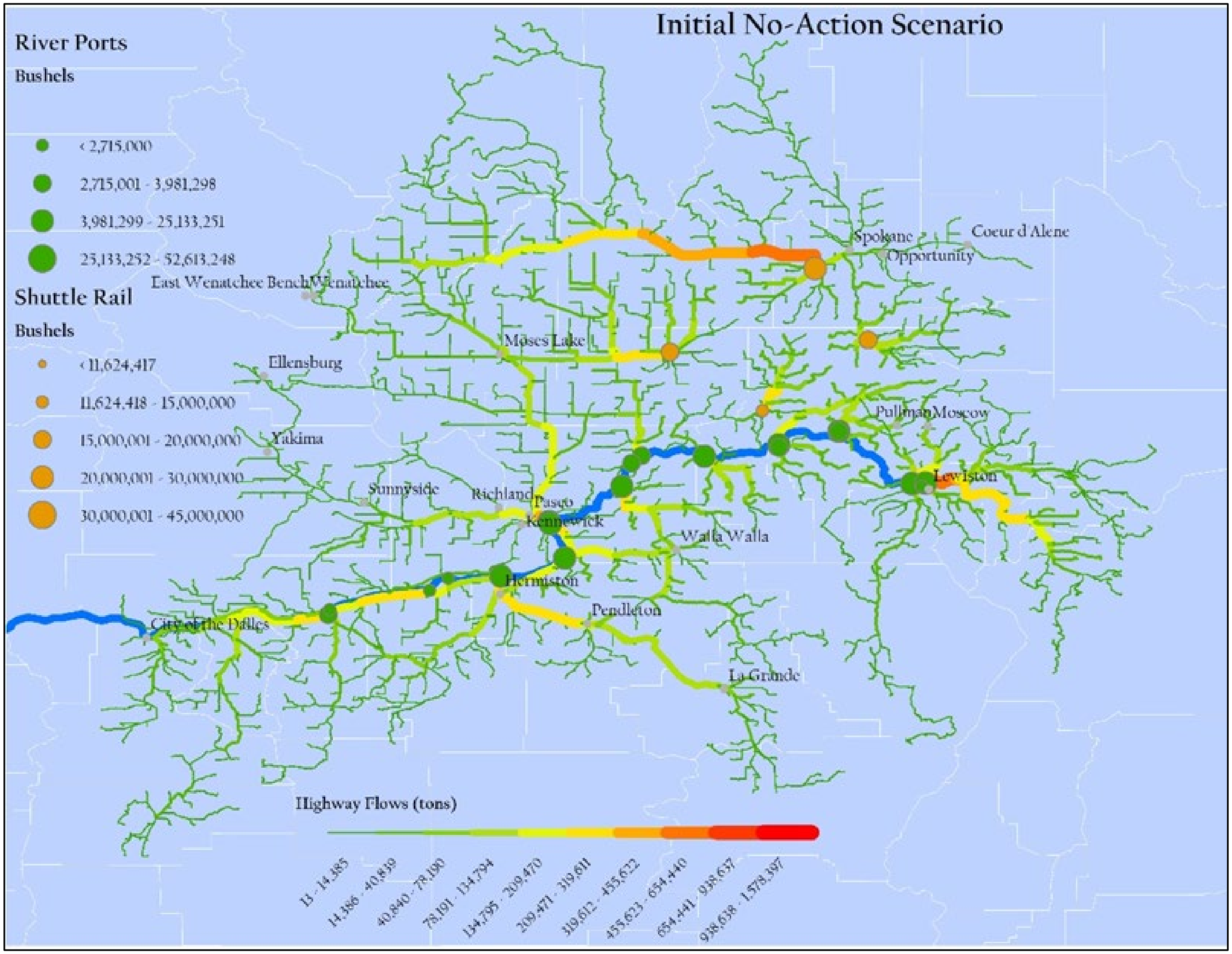



**Figure 3-211. No Action Alternative Shipping Routes**

Source: Transportation optimization model, parameterized to reflect current conditions

#### *Dredging Activities*

Under the No Action Alternative, the navigation system would continue to be maintained as required under existing authorities and operational plans. No change or measurable difference in the average annual channel dredging volume would be expected. Based on the river mechanics analysis for the No Action Alternative, the estimated annual volume of sediment depositing in the lower Columbia River Federal Navigation Channel is around 6.68 MCY per year. Note that most of the dredging activity is in the deep-draft channel, as little dredging occurs between the confluence of the lower Snake River to Bonneville Dam on the lower Columbia River. The average annual cost for maintaining the lower Columbia River navigation channel is estimated at $67.07 million per year, based upon the annual dredging costs from 2016 to 2018. Under the No Action Alternative, it is anticipated that dredging activities and associated dredging costs would continue.

Most dredging for the shallow draft of the CSNS occurs on the Snake River at the confluence of the Clearwater River with the Snake River. No change or measurable difference in the average annual channel dredging volume is expected on the lower Snake River Based on the river mechanics analysis for the No Action Alternative, the estimated annual volume of sediment requiring dredging to maintain the lower Snake River navigation channel is 124,000 cubic yards per year at an estimated cost of $3.04 million (annual equivalent).

Current dredging operations would be anticipated to continue under the No Action Alternative. The total annualized cost of dredging for the CSNS is $70.1 million (annual equivalent).

#### Commercial Cruise Line Operations

As discussed in Section 3.10.2, *Affected Environment*, approximately 18,000 passengers cruised along the river (Pacific Northwest Waterways Association [PNWA] 2017). Passenger ridership on lower Snake River cruise lines has been growing in recent years. The Columbia River outsold the Mississippi River in 2018 for the first time, as all six operating cruise ships were sold out from May to October (Macuk 2019). One cruise company more than doubled its passenger capacity on the Columbia-Snake in 2016 with a new ship (Cruise Industry News 2015), and then introduced another large river cruise ship in 2018 (Macuk 2019). In 2019, seven river cruise ships have dedicated Columbia-Snake River itineraries (Macuk 2019). Given this, under the No Action Alternative, opportunities for commercial cruise ships would be anticipated to continue throughout the CSNS, and may increase over time. Cruise ships and other recreational boaters would continue to use the CSNS and contribute to the local economies along the route under the No Action Alternative.

#### Commercial Ferry Operations

The H&H data indicates that water surface elevations on Lake Roosevelt would be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under the No Action Alternative in average water years as well as in dry water years. As stated in Section 3.10.2, *Affected Environment*, the minimum operating elevation of the ferry is 1,229 feet NGVD29. In larger runoff years under the No Action Alternative, the ferry would be inoperable for certain periods when Lake Roosevelt is drafted deeper in April and May in order to reduce potential flooding effects downstream. In these "wet" water years, defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam, the Inchelium-Gifford Ferry would not be able to operate for approximately 27 days in the year (or 7 percent of the year in wet years). Longer inoperable periods would be expected under wetter years that require more FRM space. Under the No Action Alternative, Grand Coulee Dam is operated to provide system FRM space in Lake Roosevelt in the winter and spring months. This space requirement is determined by water supply forecasts at The Dalles and in years with higher water supply conditions space requirements can result in drafts below 1,229 feet NGVD29 in Lake Roosevelt. No other operations require drafts below this elevation.

Analysis indicates that operations of Grand Coulee Dam under the No Action Alternative would allow the same level of use of the Inchelium-Gifford Ferry as seen in the recent past. There would be no overall increase in the length of shutdowns. This general level of use and length of shutdowns in wet years would be expected to continue under the No Action Alternative.

**REGIONAL ECONOMIC EFFECTS**

**Commercial Navigation and Transportation Systems**

As described in Section 3.10.2, *Affected Environment*, the navigation industry contributes substantially to the regional economies in the study area. Ports along the river serve to encourage economic development within their district, region, and state. Wheat and other grain farming, port operation and storage facilities, barge transportation, and other commodities such as sand, gravel, forest products, and fertilizer use the river for cost-effective transportation and provide jobs and income to regional economies. These activities would continue under the No Action Alternative.

***Snake Shallow (Regions C and D)***

Under the No Action Alternative, transportation costs for individual farmers shipping grain to the Port of Portland varies according to the particular attributes of each operation, including its proximity to rail, river, and particulars of rates negotiated with farming cooperatives and shipping companies. In addition to these factors, some farmers have lower costs of operations than others. In particular, some farmers may have high costs of owning or leasing lands relative to others. Despite all of these variations, farmers in the Northwest have generally lower shipping costs relative to farmers in the Midwest, who also ship grain to the Port of Portland, but have substantially longer travel distances. As such, farmers in the Northwest would likely continue cost advantages relative to other regions under the No Action Alternative.

A small number of companies specialize in operating barges and tow boats on the CSNS. These operators employ approximately 450 employees, which range from captains and crews to tugboat operators, shipping handlers, to boat builders. Many crew members permanently reside in the greater Portland area, but some reside in upriver areas (Tidewater Barge Lines and

Shaver Transportation Company 2020). These companies report that many of their employees are long-term, having niche experience and skills that would likely be difficult to transfer to other industries. Under the No Action Alternative, these companies would continue to operate and compete with rail and truck operators for shipping business.

There are four primary commercial ports in the Snake River Shallow section that runs between Pasco, Washington, and Lewiston, Idaho. These include the Port of Lewiston, the Port of Clarkston, the Port of Whitman County (with sites at Wilma, Almota, and Central Ferry), and the Port of Garfield. These ports are important regional hubs for both the navigation industry and the wider economy. Ports often own and lease buildings, land, and storage facilities.

The Port of Lewiston reports that it contributed $390 million (2014 dollars) in direct regional spending and supported 1,840 direct jobs from businesses associated with properties owned or developed by the port in 2017 (Peterson 2014). It serves as an important regional economic hub for a variety of industries, notably in the manufacturing sector. The port itself employs seven people and operates on a budget that ranges from $1.8 million to $2.3 million (2014 dollars). Its primary sources of income are terminal revenue, rental income, and tax levies (Peterson 2014). Businesses in cities and towns around the larger ports, including Lewiston and Clarkston in particular, have evolved to maximize use of the river in its current state. In particular, a large papermill located in Lewiston, Idaho, is the largest employer in the area (Cities of Lewiston, Clarkston, and Asotin 2019). The papermill utilizes the river system for barging some of its input materials, including specialized wood chips, upriver to the facility (Clearwater Paper 2020; Tidewater Barge Lines 2020). In addition, slackwater conditions in Lewiston, Clarkston, and Asotin have made the area desirable for motor boating. As a result, a number of aluminum boat-building companies are located in these towns (Cities of Lewiston, Clarkston, and Asotin 2019). While these businesses may not utilize the commercial barges on the river, these commercial businesses benefit from the navigation system existing in its current state.

Grain elevators and other storage facilities are an important part of the commercial navigation infrastructure for many ports. The Wilma site has the capacity to store 4.6 million bushels of dry peas and grain (Port of Whitman County 2015; World Port Source 2019b). The Almota site has the capacity to store 3.7 million bushels (Port of Whitman County 2015). The Central Ferry site has the capacity to store 4.6 million bushels (Port of Whitman County 2015). The Port of Garfield owns 21 storage units (Port of Garfield 2019). The Port of Lewiston has a capacity of 9.1 million bushels of covered storage and an additional 2 million bushels of outside storage (Idaho Cooperating Agencies 2019).

Under the No Action Alternative, the shortline rail, Palouse River and Coulee City (PCC), owned by WSDOT would continue its current planning regime (draft plan published in 2019 for public review). Under the current plan, the PCC system would be improved strategically, largely to maintain critical infrastructure for existing needs, including replacing rail ties, bridges, ballasts, and other minor maintenance activities. Currently, the Washington State legislature has allocated $6.7 million every two years through 2031 to the PCC for these improvement projects. Additionally, WSDOT has plans to upgrade the entire PCC network to handle 286,000-pound cars. These upgrades are necessary to remain compliant with Class I rail industry standards. To upgrade the entire rail network to the 286,000-pound car standard, WDOT would have to invest $150 million (WSDOT 2020).

Under the No Action Alternative, highways in the region would continue to be maintained on an as-needed basis.

***Columbia Shallow (Region D)***

There are 10 primary commercial ports in the Columbia Shallow river section, which runs from Portland Oregon (below Bonneville Dam), to Pasco, Washington, below McNary Dam. These are the Port of Benton, the Port of Kennewick, the Port of Pasco, the Port of Walla Walla, the Port of Umatilla, the Port of Morrow, the Port of Arlington, the Port of The Dalles, the Port of Klickitat, and the Port of Camas-Washougal. Many of these ports play an important role in economies of the Tri-Cities area of Washington and are proud of their role in providing facilities for barge shipments of grain from the area to the seacoast terminals in addition to other commodities. The Port of Benton reports that it supports over 2,000 direct jobs (Port of Benton 2019), while the Port of Kennewick reports that it has 13 staff and supports 1,550 jobs in the area (Port of Kennewick 2019). In addition to these sites, the Ports of Hood River and Skamania are primarily recreational ports in this region.

***Deep Draft (Region D)***

There are six primary commercial ports included in the deep-draft river section, which runs from Portland, Oregon, to the ocean. These are the Port of Portland, the Port of Vancouver, the Port of St. Helens, the Port of Kalama, the Port of Longview, and the Port of Astoria. Most of the cargo that goes through the deep-draft ports is shipped directly via rail or truck from inland areas and exported, while some cargo travels down the river from the shallow-draft areas of the CSNS. Most of the regional economic effects are concentrated in the export industry, but the commerce generated by the export hub is nonetheless estimated to support 40,000 local jobs (PNWA 2017). Additional smaller commercial ports include Ilwaco, Woodland, and Chinook. In addition to these ports, the Port of Columbia County is primarily a recreational port.

**Commercial Cruise Line Operations**

Under the No Action Alternative, commercial cruise ship ridership would be anticipated to continue throughout the CSNS and may increase over time. Cruise ship passengers would continue to spend money on restaurants, souvenirs, and other recreation activities in ports, stimulating the local and regional economy under the No Action Alternative. This analysis assumes that passengers would spend approximately $124 per day (2019 dollars) on 7-day cruises (Dean Runyan Associates 2015; Port of Lewiston/Shoreline Excursions 2019). Using these assumptions, the annual 18,000 cruise ship passengers per year would spend approximately $15.6 million annually under the No Action Alternative as part of cruise line trips. These expenditures would create demand for approximately 230 jobs in the region, and would generate $6.2 million in labor income, and $17.8 million in output (sales). Most of these effects would be in Region C, with remaining expenditures in Region D.

**Commercial Ferry Operations**

Under the No Action Alternative, average daily traffic for passengers on the Inchelium-Gifford Ferry, which primarily serves the Colville Reservation, would continue to be approximately 410 passengers per day, with interruptions of service of approximately 27 consecutive days in wet water years due to lower reservoir elevations in Lake Roosevelt. "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 drawn down to accommodate higher-than-average inflows. Under the No Action Alternative, the ferry would continue to serve a role to allow community members to access services on both sides of the river, which would include expenditures on food and healthcare, among other services.

**OTHER SOCIAL EFFECTS**

**Commercial Navigation and Transportation Systems**

As described in the air quality analysis, transportation by inland navigation produces lower air emissions than other transportation modes, including rail and truck per ton-mile (Kruse, Warner, and Olson 2017). Emissions from the navigation industry would remain stable under the No Action alternative. Transportation via inland navigation also has generally lower vehicular accident rates than road or rail and does not result in road traffic (GAO 2011). As described above, port facilities in the region add to the character of river communities and contribute to a sense of community identity. Some 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 that would continue under the No Action Alternative. These aspects of the presence of ports would continue under the No Action Alternative.

**Commercial Cruise Line Operations**

Commercial cruise lines would continue to provide tourist visitation, and may continue to increase operations, under the No Action Alternative. These activities may contribute to the community identity of ports of call as important tourist destinations.

**Commercial Ferry Operations**

The Inchelium-Gifford Ferry serves an isolated tribal community by offering access and connection to local services on both sides of the river. As described in Section 3.10.2, *Affected Environment*, the ferry is important to commuters, schoolchildren, emergency services, tourists, and the tribe as a whole. The ferry would likely continue operations under the No Action Alternative. The average daily number of passengers was 410 in 2018 (CTCR 2019). This would continue under the No Action Alternative.

**SUMMARY OF EFFECTS – NO ACTION ALTERNATIVE**

The navigation industry would continue to operate on the Columbia and lower Snake Rivers with continued export activity under the No Action Alternative. The availability of low-cost barge transportation would continue to provide economical and safe shipping for a wide range of commodities up to Lewiston, Idaho. Barge companies would continue to employ workers to run barges up to Lewiston, Idaho. Ports located along both rivers would continue to provide development opportunities for communities and support jobs and income in the region. Current dredging operations would be anticipated to continue under the No Action Alternative. Air emissions associated with transportation of wheat out of the Northwest region would continue to be low relative to other shipping options. Transportation costs to Northwest farmers would continue to be low relative to inland areas.

Commercial activity associated with cruise ships would continue to bring visitors and tourist dollars to the communities along the lower Columbia and lower Snake Rivers. The Inchelium-Gifford Ferry on Lake Roosevelt would continue to provide commuters, schoolchildren, tourists, and others with convenient and low-cost transportation for daily activities and needs. Table 3-237. provides a summary of effects of navigation and transportation under the No Action Alternative.

**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.<br>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. |

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 drawn down to accommodate higher than average inflows.

### *3.10.3.3 Multiple Objective Alternative 1*

A number of planned structural measures under MO1, such as upgrading spillway weirs, are unlikely to have measurable impacts to commercial navigation or cruise lines in the CSNS because they do not affect flow or elevation of water. However, the following operational measures have the potential to affect operations on the CSNS. In particular:

*Summer Spill Stop Trigger, Modified Dworshak Summer Draft, and Planned Draft Rate at Grand Coulee* measures may alter reservoir levels and/or the quantity or the timing of the flows in the Snake River and lower Columbia River (or both) and have the potential to impact how vessels move on the CSNS. Additionally, commercial ferry operations on Lake Roosevelt potential could be affected by operational changes that result in lower reservoir levels in the early spring at Grand Coulee. Other operational measures within MO1 may have notable effects on water levels and flow in upstream regions, but these flow changes are increasingly diluted as they reach the mainstem Columbia River downstream.

**SOCIAL WELFARE EFFECTS**

**Commercial Navigation and Transportation Systems**

The H&H data used as input into the SCENT model, as presented in Table 3-238., shows that MO1 would result in a negligible change in non-normal flow days when compared to the No Action Alternative.

**Table 3-238. Changes in Average Commercial Navigation Flow Days Under Multiple Objective 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 |

Note: The "Shallow" categories include both the Columbia-Snake Shallow category, which refers to traffic that traveled on both the Columbia and Snake Rivers, and the Columbia Shallow, which presents the impact to traffic only traveling on the Columbia.
Source: SCENT modeling

Table 3-239. for MO1 presents anticipated changes in average annual operating costs that would occur under MO1 as a result of flow changes. Costs of operations under normal flow range categories would not be affected under MO1.[9]

The average annual change in transportation costs under MO1 in the Columbia-Snake Shallow 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.

increased average annual costs would occur under MO1 for Columbia Shallow operations. The average annual extra transportation costs for transportation in the deep-draft segment are estimated to be $4,000 more than the No Action Alternative under MO1. The driver behind the minor increases in costs is additional days of low flow in late summer causing draft restrictions for some vessels. These increases in low flow conditions are primarily associated with the combination of the *Lake Roosevelt Additional Water Supply* and *Modified Dworshak Summer Draft* measures.

As shown in Table 3-239., the total increase in average annual costs to commercial navigation operations would be approximately $14,000.

**Table 3-239. Changes in Average Annual Costs of Commercial Navigation Operations Under Multiple Objective Alternative 1 Relative to No Action Alternative (2019 Dollars), over 50 years**

| | Change in Costs Associated with Flow Range Categories | | | | Changes in Costs Associated with Draft Restrictions | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **River Segment** | **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** |

Note: 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. These effects are all within one standard deviation of the No Action Alternative conditions. Costs of operations under normal flow range categories are not anticipated to be affected under any alternatives and are therefore excluded from the table. Numbers may not sum due to rounding.

Source: SCENT modeling

**Dredging Operations**

Negligible changes to dredging operations would occur under MO1 because anticipated changes to river flows and stages would not have effects on sediment transport in areas used by commercial navigation.

**Commercial Cruise Line Operations**

Negligible changes to cruise ship operations would occur under MO1 because anticipated changes to river flows and stages would not affect timing or use of the navigation channel.

**Commercial Ferry Operations**

H&H data indicates that water surface elevations on Lake Roosevelt would be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under MO1 in average water years as well as in dry water years. In larger runoff years, the ferry would be inoperable for certain periods when Lake Roosevelt is drafted deeper in April and May in order to reduce potential flooding effects downstream, similar to the No Action Alternative. In these "wet" water years, defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam, the Inchelium-Gifford Ferry would not be able to operate for approximately 36 consecutive days in the year under MO1 (or 10 percent of the year in wet years), which is 9 days more than under the No Action Alternative (a 33 percent increase). This would result from changes in operations at Grand Coulee Dam under this alternative. The average daily number of passengers on the ferry is 410 (FHWA 2017). At this rate, approximately 3,700 ferry trips could be affected in wet years by this change. Longer inoperable periods would be expected in wetter years that require more FRM space. This is likely to be caused by the *Winter System FRM Space*, *Planned Draft Rate at Grand Coulee*, and *Update System FRM Calculation* measures.

**REGIONAL ECONOMIC EFFECTS**

**Commercial Navigation and Transportation Systems**

Average annual costs to the navigation industry would increase by approximately $14,000 under MO1. These effects are not likely to result in noticeable effects to regional economies.

**Commercial Cruise Line Operations**

Negligible effects to commercial cruise line operations would occur under MO1. Given this, effects to regional economies are not anticipated.

**Commercial Ferry Operations**

MO1 would result in a loss of 9 days of operations by the Inchelium-Gifford Ferry in wet years (a 33 percent change from the No Action Alternative), which could represent 3,700 fewer ferry trips. Longer inoperable periods would be expected in wetter years that require more FRM space. In those years and for those days, expenditures associated with these trips via ferry would likely be delayed or would not take place in the same locations.

## OTHER SOCIAL EFFECTS

### Commercial Navigation and Transportation Systems

Average annual costs to the navigation industry would increase by approximately $14,000 under MO1. These effects are not likely to result in noticeable changes to other social effects, including changes in air emissions accident rates, or infrastructure costs under MO1.

### Commercial Cruise Line Operations

Negligible effects to commercial cruise line operations would occur under MO1. Given this, changes to other social effects are not anticipated under MO1.

### Commercial Ferry Operations

MO1 would result in a loss of 9 days of operations by the Inchelium-Gifford Ferry in wet years. Longer inoperable periods would be expected in wetter years that require more FRM space. In those years and for those days, travel from remote communities that use the ferry would not be able to occur. Changes in access by the remote communities during those days would reduce access to healthcare and educational facilities, in addition to food and shopping resources. Without the ferry, commuters and others who need to make the trip must take a 70-mile detour, which adds substantial mileage, gas costs, time, air emissions, and other effects (Spokesman-Review 2017). Since the ferry is free and reduces driving time and distance, the loss of ferry service would create additional transportation costs.

## SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 1

MO1 would result in negligible increases in average annual costs for deep-draft navigation and shallow-draft navigation. The increase in costs for deep-draft navigation would result from additional days of low flows, which would require an increase in the number of tug operations. Overall, this would represent a change in average annual costs of $14,000 to the industry, representing a negligible (less than 0.1 percent) increase in costs in comparison to the No Action Alternative. Effects to the cruise line industry would be negligible.

Adverse effects would occur to the Inchelium-Gifford Ferry because it would be able to operate 9 days fewer under MO1 than under the No Action Alternative in wet years, for a total of 36 consecutive days, which could represent 3,700 ferry trips. Longer inoperable periods would be expected in wetter years that require more FRM space. During those years minor social welfare effects could be experienced due to the longer inoperable period. Minor regional economic effects due to loss or redistribution of expenditures associated with the ferry trips could also occur. Changes in access to healthcare and educational facilities, in addition to food and shopping resources, could result in moderate adverse effects. Other ferries would not be affected under MO1.

Table 3-240. provides a summary of the navigation and transportation system effects of MO1.

**Table 3-240. Changes in Economic Effects of Navigation and Transportation Under Multiple 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. |

[1/] "Wet" water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam.

#### *3.10.3.4 Multiple Objective Alternative 2*

Similar to MO1, a number of planned structural measures under MO2, such as installing 'fish-friendly' high efficiency turbines at John Day or adding additional surface passage routes at specific projects, are unlikely to have measurable impacts to commercial navigation or cruise lines in the CSNS because they do not affect flow or elevation of water. However, the following operational measures have the potential to affect operations on the CSNS by altering reservoir levels and/or the quantity or the timing of the flows in the lower Snake and lower Columbia River (or both).

*Spill to 110% TDG*, *Ramping Rates for Safety*, and *Full Range Reservoir Operations* measures could alter reservoir levels and/or the quantity or the timing of the flows in the lower Snake and lower Columbia Rivers (or both), and have the potential to affect operations on the CSNS.

Under MO2, impacts due to operational changes would likely be similar in the short-term versus the longer-term operation of the system, assuming that the operational changes would begin while structural measures were implemented.

Commercial ferry operations on Lake Roosevelt have potential to be affected by operational changes at Grand Coulee that result in lower reservoir levels earlier in the year.

**SOCIAL WELFARE EFFECTS**

**Commercial Navigation and Transportation Systems**

The H&H data used as input into the SCENT model, as presented in Table 3-241., shows that MO2 would have slightly fewer days in normal and high flow conditions and a greater number of days in the low category than the No Action Alternative.

**Table 3-241. Changes in Average Commercial Navigation Flow Days Under Multiple Objective 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) |

Note: The "Shallow" categories include both the Columbia-Snake Shallow category, which refers to traffic that traveled on both the Columbia and Snake Rivers, and the Columbia Shallow, which presents the impact to traffic only traveling on the Columbia.
Source: SCENT modeling

Table 3-242. for Alternative MO2 presents anticipated changes in average annual operating costs that would occur under MO2. Costs of operations under normal flow range categories would not be affected under MO2. The impact to shallow-draft traffic equates to a decrease in average annual costs of approximately $18,000. However, low flow conditions affect the costs for deep-draft traffic, which would see an increase of $178,000. The combination of shallow- and deep-draft effects would result in an increase in average annual costs to commercial navigation operations of $160,000.

**Table 3-242. Changes in Average Annual Costs of Commercial Navigation Operations Under Multiple Objective Alternative 2 Relative to No Action Alternative (2019 Dollars), over 50 years**

| | Change in Costs Associated with Flow Range Categories | | | | Changes in Costs Associated with Draft Restrictions | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **River Segment** | **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** |

Note: 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. These effects are all within one standard deviation of the No Action Alternative conditions. Costs of operations under normal flow range categories are not anticipated to be affected under any alternatives and are therefore excluded from the table. Numbers may not sum due to rounding.

Source: SCENT modeling

**Dredging Operations**

Negligible changes to dredging operations would occur under MO2 because anticipated changes to river flows and stages would not have effects on sediment transport in areas used by commercial navigation.

**Commercial Cruise Line Operations**

Negligible changes to cruise ship operations would occur under MO2 because anticipated changes to river flows and stages would not affect timing or use of the navigation channel by the industry.

**Commercial Ferry Operations**

The H&H modeling data indicate that water surface elevations on Lake Roosevelt would be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under MO2 in average water years as well as in dry water years, similar to the No Action Alternative. In larger runoff years, the ferry would be inoperable for certain periods when Lake Roosevelt would be lowered in April and May in order to reduce potential flooding effects downstream. In these wet years (defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam), the Inchelium-Gifford Ferry would not be able to operate for approximately 36 consecutive days in the year under MO2 (or 10 percent of the year in wet years), which would be 9 days more than under the No Action Alternative (an increase of 33 percent). The average daily number of passengers on the ferry is 410 (CTCR 2019). At this rate, approximately 3,700 ferry trips could be affected in wet years under MO2. Longer inoperable periods would be expected in wetter years that require more FRM space.

**REGIONAL ECONOMIC EFFECTS**

**Commercial Navigation and Transportation Systems**

Average annual costs to the navigation industry would increase by approximately $160,000 under MO2. These effects are not likely to result in noticeable effects to regional economies.

**Commercial Cruise Line Operations**

Negligible effects to commercial cruise line operations would occur under MO2. Given this, effects to regional economies are not anticipated.

**Commercial Ferry Operations**

As stated above, MO2 would result in a loss of 9 days of operations by the Inchelium-Gifford Ferry in wet years (a 33 percent change from the No Action Alternative), which could represent 3,700 fewer ferry trips. Longer inoperable periods would be expected in wetter years that require more FRM space. In those years and for those days, expenditures associated with these trips via ferry would likely be delayed or would not take place in the same locations.

## OTHER SOCIAL EFFECTS

### Commercial Navigation and Transportation Systems

Average annual costs to the navigation industry would increase by approximately $160,000 under MO2. These effects are not likely to result in noticeable changes to other social effects, including changes in air emissions.

### Commercial Cruise Line Operations

Negligible effects to commercial cruise line operations would occur under MO2. Given this, changes to other social effects are not anticipated under MO2.

### Commercial Ferry Operations

As stated above, MO2 would result in a loss of an additional 9 days of operations by the Inchelium-Gifford Ferry in wet years (a 33 percent increase from the No Action Alternative) for a total of 36 consecutive days when the ferry would not be able to operate. Longer inoperable periods would be expected in wetter years that require more FRM space, reducing access to remote communities on the Colville Reservation that use the ferry. Changes in access by the remote communities during those days would reduce access to healthcare and educational facilities, in addition to food and shopping resources. Without the ferry, commuters and others who need to make the trip must take a 70-mile detour, which adds substantial mileage, gas costs, time, air emissions, and other effects (Spokesman-Review 2017). Since the ferry is free and reduces driving time and distance, the loss of ferry service would create additional transportation costs.

## SUMMARY OF EFFECTS

MO2 would result in negligible increases in average annual costs for deep-draft navigation and a minor decrease in costs for shallow-draft navigation. The increase in costs for deep-draft navigation would result from additional days of low flows, which would require an increase in the number of tug operations. Overall, this would represent a change in average annual costs of $160,000 to the industry, representing a negligible (less than 0.1 percent) increase in costs in comparison to the No Action Alternative. Effects to the cruise line industry would be negligible.

Moderate effects would occur to the Inchelium-Gifford Ferry, as while no effects on ferry operations would occur in normal or dry water years, in wet years, the ferry could operate 9 days fewer under MO2 than under the No Action Alternative in wet years (for a total of 36 consecutive days when the ferry would not operate annually), which could represent 3,700 fewer ferry trips. During those years minor social welfare effects could be experienced due to the longer inoperable period. Minor effects due to loss or redistribution of expenditures associated with the ferry trips could also occur. Changes in access to healthcare and educational facilities, in addition to food and shopping resources, could result in moderate adverse effects. Other ferries would not be affected under MO2.

Table 3-243. provides a summary of the navigation and transportation system effects of MO2.

**Table 3-243. Changes in Economic Effects of Navigation and Transportation Under Multiple 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. |

1/ "Wet" water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam.

### *3.10.3.5 Multiple Objective Alternative 3*

The primary structural change in MO3 is the *Breach Snake Embankments* measure, which removes the earthen embankment portions of four projects located on the lower Snake River: Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. This measure would result in substantial effects by curtailing commercial navigation on the Snake River beyond Ice Harbor. The Columbia River shallow-draft channel would still be operable; however, access to the shallow-draft channel from certain port facilities at the confluence of the Snake with the Columbia and within the McNary Reservoir would require additional dredging.

Along with breaching the four lower Snake River dams, MO3 includes some operational measures that also have the potential to affect operations on the Columbia shallow- and deep-draft channels. The *Spring Spill to 120% TDG*, *Ramping Rates for Safety*, and *John Day Full Pool* measures would alter reservoir levels or the quantity or the timing of the flows in the lower Columbia River (or both), and therefore, have the potential to result in major effects in how vessels move on the CSNS. A number of planned structural measures, such as modifying existing fish passage systems, would have no effects to commercial navigation or cruise lines in the CSNS because they do not affect flow or elevation of water.

**SOCIAL WELFARE EFFECTS**

**Commercial Navigation and Transportation Systems**

The transportation model developed to measure the impact of alternative river navigation scenarios under MO3 is a constrained optimization model designed to capture the choices currently facing shippers that use the Columbia-Snake River System, particularly the navigable portions of the lower Snake River. According to the lock reports maintained by the Corps, the commodities shipped on the system are predominantly grain (wheat and barley) for downriver barge movements and fuel for upriver shipments. There are a variety of other commodities moved in smaller volumes, but grain (wheat and barley) comprises the majority (more than 87 percent in 2018) of the downbound tonnage moved on the lower Snake River and 62 percent of overall tonnage on the lower Snake River. The model captures the choices faced by shippers moving these products to market. Generally, data compiled from a variety of sources provides the necessary information to parameterize the model and establish the constraints and choice alternatives, representing current conditions, as they exist. Fuel comprises the majority of upbound tonnage on the lower Snake River (91 percent in 2018), most of which terminates river passage above Pasco, Washington. Fuel comprises 27 percent of overall tonnage on the lower Snake River. Fuel movements are not modeled due to data limitations and uncertainty of how movements may be affected under MO3. The Columbia River shallow-draft channel would still be operable; however, access to the shallow-draft channel from certain port facilities at the confluence of the Snake with the Columbia and within the McNary Pool would require additional dredging. However, given the safety concerns associated with fuel movements, it is unclear if fuel companies would continue movements in the McNary Pool to Pasco, Washington.

Additional details on the data and model parameterization are available in Appendix L, *Navigation*.

Evaluating the impact of removing the lower Snake River locks and barge navigation above Pasco, Washington, is completed by modifying the transportation optimization model by not allowing shipments on river terminals along the lower Snake River.[10] It is likely that the facilities 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.

truck; however, these facilities are assumed to be closed for purposes of this analysis. To the extent that some terminals on the lower Snake River could continue to be used, the effects to shippers would be lower than model results suggest. Economic impacts on shippers would be most acute in the short term, as shippers, ports, port services and related companies have invested in equipment and labor that is suited to current conditions. As the industry adapts over time, more rail capacity and associated storage would likely be added in the region to accommodate freight affected by loss of river navigation on the lower Snake River. In addition, highways would be utilized more heavily. Ports have commented that the availability of land at port sites may constrain their ability to add rail capacity, as well as the time-intensive and uncertain permitting process to augment rail capacity (Port of Lewiston 2019).

Rail price increases are constrained by the market. By removing the option of shipment via barge, prices on the rail lines are likely to increase. As described in the following sections, three scenarios are considered for understanding potential effects of MO3: Scenario 1 assumes rail rates would not increase; Scenario 2 assumes rail rates would increase by 25 percent regionwide; and Scenario 3 assumes the rail rates would increase by 50 percent regionwide. Some stakeholders have stated their opinion that a 50 percent rail rate increase seems too low because railroads would take advantage of monopolistic pricing opportunities absent an operational Snake River channel as an alternative (e.g., Idaho Cooperating Agencies 2019). However, others agree with the assessment that 50 percent is likely to be a reasonable upper-bound estimate. As shown in the modeling results below, an increase of 50 percent in rail rates would be high enough to entice shipping volume back to barge movements at the Tri-Cities, and would therefore be likely to constrain increases higher than 50 percent. At the highest end, rail prices would be constrained by costs to ship via truck, which is generally the most expensive option. Some commenters have expressed concern that because rail is privately owned, it is less reliably available than the river system (e.g., Idaho Cooperating Agencies 2019). Shippers have expressed some concern that private decisions related to making train cars available based on prices of other commodities would also affect the reliability of the rail lines for supplying adequate capacity to serve the shipping needs (Port of Lewiston and shippers 2019). Commenters have further stated it is difficult to secure a unit train on short notice to take advantages of seasonal demand (Idaho Cooperating Agencies 2019).

The modeling scenarios presented below are used to capture a reasonable range of effects on commodity movements and transportation costs, given the range of uncertainties surrounding how rates may change if the lower Snake River navigation channel is no longer available. Along with how movements and transportation costs would change, potential effects on infrastructure and the improvements that would be needed are described.

***Scenario 1: Effects of Dam Breach on Grain Transportation Assuming Constant Rail Rate***

Under Scenario 1, commodities that would have been transported on the lower Snake River are assumed to be transported using the next least cost alternative. Costs of alternative shipping modes, including rail, are assumed not to change under this scenario. This scenario is likely to be a low estimate, as rail rates are likely to increase following dam breach. However, this scenario would also lead to the highest increase in rail usage because of the relative cost of rail compared to truck and/or truck and barge. As such, it captures the largest increase in demand for rail that could be expected under any scenario. In this way, it identifies the upper bound of potential demands on rail and rail infrastructure.

Scenario 1 is heavily dependent on two assumptions. First, the scenario assumes that existing shuttle rail facilities would be able to accommodate with some limited expansion for most of the grain that otherwise would have used the lower Snake River ports (slightly more than double existing shuttle rail facility volumes). This assumption appears as a reasonable starting point because shippers have reported that shuttle rail facilities can accommodate up to 25 million bushels per year with some storage adjustments, which is equivalent to 0.75 million tons per facility (Idaho Cooperating Agencies 2019). As such, total capacity of these facilities would be approximately 3 million tons, which is more than the total grain volume on the river in recent years. Second, the model assumes that the shortline railroads would be able to accommodate increased volumes going to shuttle rail facilities. It appears likely that improvements to the shortline rail lines would be required to accommodate this increased volume. Potential costs associated with required shortline rail improvements are discussed in the Regional Economic Effects section, below. In addition, ports have commented that because grain does not move at the same export volume throughout the year, but rather is dependent on world demand, issues could exist in providing adequate rail capacity at critical times (Port of Lewiston 2019).

Under Scenario 1, the total costs to transport grain to market would increase by 10 percent from $145 million to $159 million, representing an increase of $14 million, or approximately 7 cents per bushel. The cost increases to specific shippers would depend upon location and vary throughout the region, depending on transportation options at each location. Generally, those grain shippers that are the furthest from alternate shipping locations (shuttle rail facilities or river ports on the Columbia River) would be the most negatively impacted. Note, cost scenarios for specific farmers are presented below in the Regional Economic Effects section.

The primary reason that the transportation costs would not increase more dramatically under Scenario 1 is the assumed availability of the four shuttle rail facilities to absorb these shipments (in Ritzfield, Washington [Templin Facility], and Four Lakes, Washington [High Line Facility], 2 hours from Pasco, Washington, via highway; in Rosalia, Washington [McCoy Facility], south of Spokane and 2.5 hours from Pasco, Washington; and a new facility in Lacrosse, Washington [Endicott Facility], which is located closest to the Snake River and 1.5 hours from Pasco, Washington). As discussed above, each facility currently has approximately 25 million bushels of capacity, or the ability to handle 0.75 million tons per year, or 3 million tons across all of the facilities. Under MO3 Scenario 1, the total shuttle rail freight volume would almost double from current volumes, increasing from 71 million bushels under the No Action Alternative to 138 million bushels under Scenario 1. This would represent a substantial increase in shuttle rail volume that would exceed current shuttle rail capacities of 100 million bushels. As such, increased capacity would be needed at the four currently operating shuttle rail facilities under Scenario 1. Due to this required increased in capacity, it would seem that this increase would be unlikely to occur without an associated increase in rail rates. The majority of the increase in grain shipments by shuttle rail would arrive from other grain elevators with rail via rail, as opposed to truck shipments on highways. The analysis assumes that shortline railroads would be primarily responsible for this in rail volume increase; however, uncertainty exists about whether shortline railroads would be able to adjust operations and/or facilities to accommodate the increase in volume.

Given that the Snake River ports would be no longer accessible, the aggregate amount of grain coming directly from farms to river ports would decrease under Scenario 1. The total grain volume accessing any river port along the CSNS, moving directly from farm to river ports via truck at or below Pasco, Washington, would decrease from 125 to 45 million bushels (a decrease of 64 percent), while the average distance of truck trips for those shipments would increase from 39 to 48 miles (an increase of 22 percent relative to the No Action Alternative).

Columbia River barge transportation would continue to be important in the region downstream of Pasco under MO3, representing 32 percent of all grain moving to export (compared to 65 percent under the No Action Alternative). Grain transported on the river is assumed to arrive via truck.

The total impacts to transportation infrastructure (measured in ton-miles) would increase from 2.37 to 2.47 billion ton-miles, an increase of 96 million ton-miles, under MO3 Scenario 1 (representing an increase of 4.1 percent compared with the No Action Alternative). Highway (truck) ton-miles would increase from 464 million to 551 million, while barge ton-miles would decrease from 1.09 billion to 391 million on the CSNS.

Under Scenario 1, the decreasing barge volume could adversely affect companies that particularly depend on this transit mode, such as tow boat companies. The increase in highway ton-miles is primarily due to grain shippers moving commodities to rail shuttle facilities and also to commodities being trucked farther to river ports on the middle Columbia, below the closure, than would be anticipated under the No Action Alternative.

Assuming constant rail rates, railroad ton-miles would increase the most under Scenario 1 (No Rail Rate Increase), increasing from 819 million ton-miles under the No Action Alternative to 1.5 billion ton-miles under MO3. This would include a substantial increase in volume at each of the four shuttle rail facilities, particularly for the Lacrosse facility given its close proximity to the river and the fact that it would be the most likely alternative for production impacted by river closure. This increase would represent an increase in the number of unit trains (with approximately 110 cars per train) from approximately four trains to approximately eight trains per month at each shuttle rail facility. Overall, the annual number of shuttle rail unit train trips in the region would increase by 185, and the number of shuttle rail cars loaded would increase by over 20,000. This would represent an increase of 94 percent over current shuttle rail activity.

A summary of the changes in grain flows, transportation costs, and ton-miles under the MO3 Scenario 1 are provided in Table 3-244.. Figure 3-212 depicts shipping patterns by mode for grain shippers under MO3 Scenario 1. Specifically, the figure illustrates the highway flows of grain shipments, the location of origination points used in the transportation optimization model, river port terminals along the Columbia-Snake navigation channel (green circles) and shuttle rail terminals (orange circles). Once the lower Snake River ports are eliminated in this scenario, the shuttle rail facilities accommodate the majority of grain displaced from the lower Snake River terminals. Given this, the intensity of highway flows changes and the thickness of 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)** | **–** |

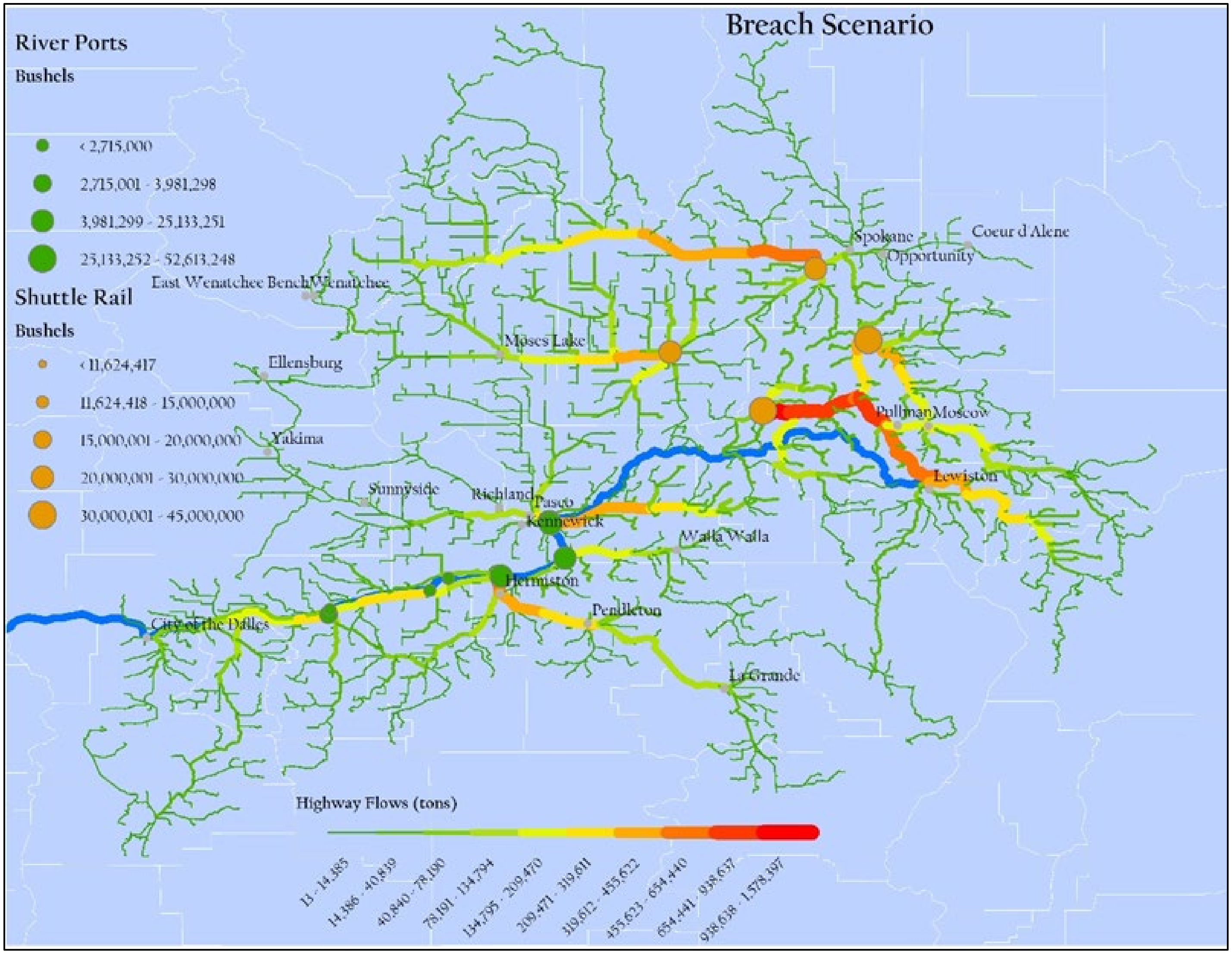



**Figure 3-212. Multiple Objective Alternative 3 Scenario 1: Shipping Routes by Mode**

Source: Transportation optimization model, parameterized to reflect current conditions.

***Scenario 2: Effects of Dam Breach on Grain Transportation Assuming Rail Rate Increase of 25 Percent***

Unlike Scenario 1, Scenario 2 assumes that rail rates would increase by 25 percent above the No Action Alternative rates. Increasing rail rates by 25 and then 50 percent (Scenario 3) allow for improved understanding of modal shift and pricing sensitivity between rail and river transport. As under MO3 Scenario 1, 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) would be the most negatively impacted.

Increasing rail rates by 25 percent in Scenario 2 would result in a total cost of $176 million, a $31 million (22 percent) increase in costs (in comparison to the $13 million increase under Scenario 1), and is equivalent to an average transportation cost of 87 cents per bushel. A transportation cost of 87 cents per bushel equates to an increase of 15 cents from the No Action Alternative (a percentage increase of 22). Some individual shippers may experience increases that are more than double this amount, depending on their location.

The distribution of volume moving via different transportation modes would change substantially under this scenario, as the increase in rail rates would shift grain shipments away from shuttle rail lines to a combination of truck and barge. In Scenario 2, the total volume moving by shuttle rail to export ports would be 120 million bushels, a 67 percent increase from the No Action Alternative and a decrease of 14 percent from Scenario 1. The total volume moving by barge, 83 million bushels, decreases from the No Action Alternative estimate of 131 million (a decrease of 37 percent) and increases from the Scenario 1 estimate of 64 million (an increase of 29 percent). Note, river ports still operating on the Columbia River at Pasco, Washington, would experience a large volume increase, mostly from shipments arriving via truck traveling longer distances to access the river ports.

Total ton-miles under Scenario 2 would increase from the No Action Alternative to 2.46 billion (an increase of 93 million compared to the No Action Alternative). In this scenario, barge ton-miles would substantially decrease from the No Action Alternative to 517 million while both truck and rail would increase from the No Action Alternative to 613 million and 1.33 billion ton-miles, respectfully. As in Scenario 1, this modal change would create a substantial increase in volume at each of the four shuttle rail facilities. Under Scenario 2, this increase would represent an increase in the number of unit trains (with approximately 110 cars per train) from approximately four trains to approximately seven trains per month at each shuttle rail facility. Overall, the annual number of shuttle rail unit train trips in the region would increase by 133, and the number of shuttle rail cars loaded would increase by over 15,000. This would represent an increase of 35 percent over current shuttle rail activity.

The changes in grain flows, transportation costs, and ton-miles under MO3 under Scenario 2 are summarized in Table 3-245. Figure 3-213 provides a visual depiction of commodity movements by mode for Scenario 2. As in Table 3-245, Figure 3-213 depicts shipping patterns by mode for grain shippers under MO3, Scenario 2. Specifically, the figure illustrates the highway flows of grain shipments, the location of origination points used in the transportation optimization model, river port terminals along the Columbia-Snake navigation channel (green circles) and shuttle rail terminals (orange circles). As shown, when rail rates assumed to increase by 25 percent after the breach, a larger proportion of the grain is now trucked to the Tri-Cities area, as indicated by the thick, orange-red lines in Figure 3-213.

**Table 3-245. Multiple Objective Alternative 3 Scenario 2 (25 percent Rail Rate Increase): 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 | **-** |

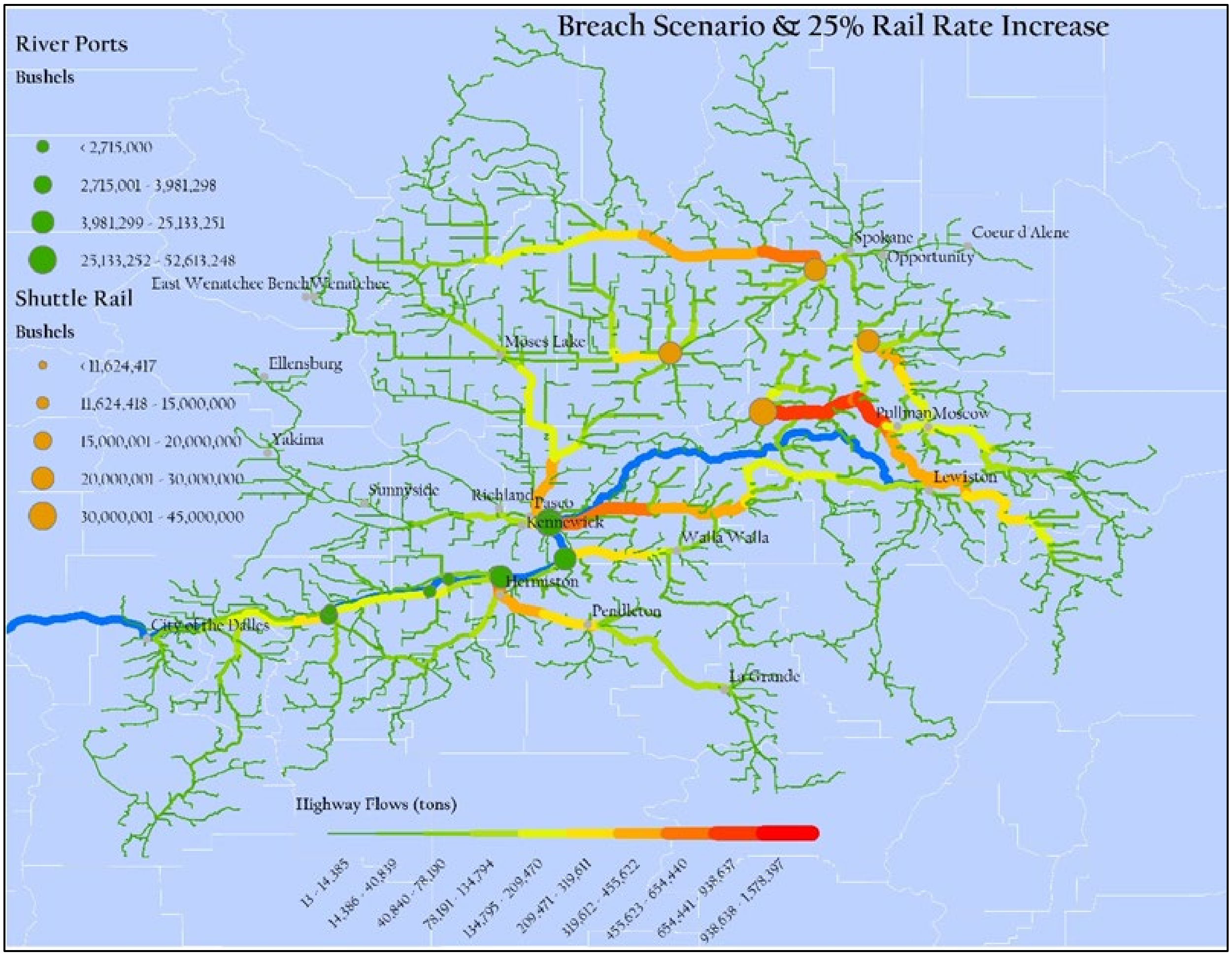



**Figure 3-213. Multiple Objective Alternative 3 Scenario 2 (25 Percent Rail Rate Increase): Shipping Routes by Mode**

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) would be the most negatively impacted. The Regional Economic Effects section describes farming effects in more detail.

Increasing rail rates by 50 percent in Scenario 3 under MO3 would result in total transportation costs of approximately $193 million, a $48 million increase in costs (in comparison to the $13 million increase under Scenario 1 and to the $31 million increase under Scenario 2), and is equivalent to 95 cents per bushel transportation costs. This would represent a 24 cent per bushel increase from the No Action Alternative (an increase of 33 percent when compared with the No Action Alternative). While this increase would represent an increase of 33 percent on average, some individual shippers may experience increases that are more than double this amount, depending on their location.

The TOM model finds that the distribution of volume moving via different transportation modes would change substantially under this scenario, as the increase in rail rates would dramatically shift grain shipments away from shuttle rail lines. Instead shippers would move grain either by rail to river terminals on the Columbia River, or by truck to river terminals on the Columbia River. The total volume moving by shuttle rail to export ports would increase under Scenario 3 to 72 million bushels, which is a 1.1 percent increase compared to the No Action Alternative. The volume moving by barge (130 million bushels) would be higher than under Scenario 1 (64 million bushels), and would be slightly lower than would have occurred under the No Action Alternative (131 million bushels), representing a decrease of 0.6 percent. River ports still operating on the Columbia River at Pasco, Washington, would experience a large volume increase, mostly from shipments arriving via truck traveling longer distances to access the river ports.[11]

Total ton-miles under Scenario 3 would increase to 2.5 billion, a 5 percent increase from the No Action Alternative. Total truck ton-miles would increase dramatically to 855 million ton-miles (391 million more than under the No Action Alternative). Under MO3 Scenario 3, there would be a 33 percent increase in total transportation cost regionwide. However, some shippers may experience increases that are more than double this amount, depending on location (refer to the Regional Economic Effects section for a discussion of costs to agricultural operations). Unlike Scenarios 1 and 2, modal changes under Scenario 3 would only create a small increase in volume at each of the four shuttle rail facilities. Consistent with the No Action Alternative, each shuttle rail facility would receive approximately four trains per month. Overall, the annual number of shuttle rail unit train trips in the region would increase by two, and the number of shuttle rail cars loaded would increase by approximately 240. This would represent a less than 1 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.

The changes in grain flows, transportation costs, and ton-miles under the MO3 under Scenario 3 are summarized in Table 3-246.. Figure 3-2148 provides a visual depiction of commodity movements by mode for Scenario 3. As in Table 3-246., Figure 3-214 depicts shipping patterns by mode for grain shippers under MO3, Scenario 3. Specifically, the figure illustrates the highway flows of grain shipments, the location of origination points used in the transportation optimization model, river port terminals along the Columbia-Snake navigation channel (green circles) and shuttle rail terminals (orange circles). As shown, when rail rates assumed to increase by 50 percent after the breach, a larger proportion of the grain is now trucked to the Tri-Cities area, as indicated by the thick, dark red lines in Figure 3-214.

**Table 3-246. Multiple Objective Alternative 3 Scenario 3 (50 Percent Rail Rate Increase): 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 | 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 | – |

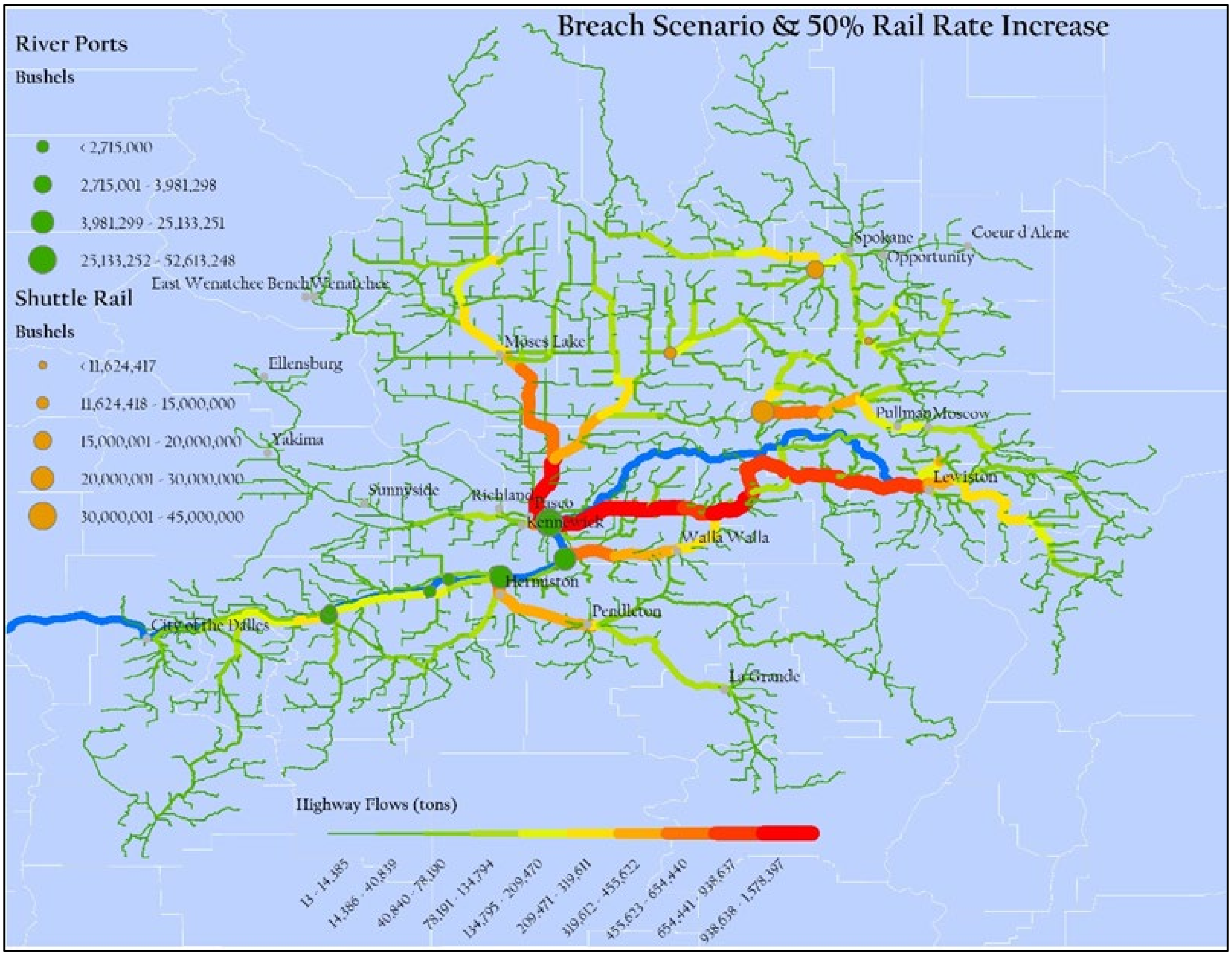



**Figure 3-214. Multiple Objective Alternative 3, Scenario 3 (50 Percent Rail Rate Increase): Shipping Routes by Mode**

### Effects on Other Commodities

As described above, the modeling effort associated with increased costs to transport goods focused on grain shippers because these shipments comprise the majority (more than 87 percent) of downriver shipments. However, it is worth noting that other commodities shipped on the system would also not be able to utilize the system following dam breach. The total volume of these commodities is relatively small; however, the system provides some unique services associated with these commodities.

Wood Chips

Wood chips travel both upriver and down river in relatively small volumes in service of papermills that are located on or near the lower Snake River. As described in Section 3.10.2, *Affected Environment*, a papermill in Lewiston receives regular shipments of wood chips that are used as a process input. While comprising a small overall volume, there would be increased costs to this industry under MO3 associated with shipping these inputs by other means (likely via truck).

Fuel/Petroleum Products

Primarily an upriver movement that ends above McNary Dam, petroleum products travel via barge in the shallow system and comprise the primary upbound commodity on the lower Snake River segment (100 million tons in 2018) (Waterborne Commerce 2020). Because these shipments currently terminate below Ice Harbor Dam and do not utilize the river channel, they would not be directly affected by dam removal. However, barge companies report that these shippers are very sensitive to increased risk and are concerned that potential needs for dredging facilities in the McNary pool would discourage those shippers from utilizing the system even if it continues to be made available by periodic dredging (Shaver Transportation Company 2020).

Shipments of Oversized Objects

As described in the introduction to this section, the CSNS provides a unique water route to transport oversized cargo into the interior of the United States. Cargo transported upriver to the Port of Lewiston can then be transported on U.S. Highway 12, which has no cargo height restrictions. U.S. Highway 12 has no overpasses and similarly there are routes in Montana that have no height restrictions (Idaho Cooperating Agencies, January 2020). While the system transports shipments of this type infrequently, it is a unique service that could not be replaced by road or rail alone.

***Effects of Flow Changes Other than Breach (SCENT Results)***

Similar to MO1, MO2, and MO4, the SCENT model, which captures how changes in flow days affects commercial navigation costs, was used to evaluate effects of MO3. Effects of MO3 related to flow changes outside of the lower Snake River were negligible, resulting in an increase in non-normal flow days of less than 0.1 day. These flow changes would result in decreases in costs of shallow-draft and deep-draft commercial navigation of approximately $31,000 and $186,000 in average annual costs, respectively. The combination of shallow- and deep-draft effects results in a decrease in average annual costs to commercial navigation operations of $217,000. These effects are all within one standard deviation of the No Action Alternative conditions.

**Dredging Operations**

As described in Section 3.10.3.5, *River Mechanics*, and in Appendix C, *River Mechanics*, under MO3 there would be an increased amount of sediment passing from the lower Snake River into the Columbia River. The MO3 construction period is estimated to be 2 years, beginning with breaching and drawdown of the upper two projects occurring during the first construction year, and breaching and drawdowns of the lower two Snake River projects during the second year. Modeling indicates that sediment volumes and concentrations passing out of the lower Snake River would be elevated immediately following drawdown, and for the two years that follow as the system transitions from reservoirs to run of river. After the near-term period, sediment modeling indicates that there would be an estimated period of 2 to 7 years where lower Snake River would continue moving higher volumes of sediment, establishing a new dynamic equilibrium. Over the long term the lower Snake River is expected to eventually reach a new quasi-equilibrium condition and largely pass incoming sediment loads.

Based upon these changing sediment patterns and timing, dredging operations within the McNary pool (Wallulla Reservoir) and at the confluence of the lower Snake River would increase substantially, especially during and directly following dam breaching (between years 2 and 7 post dam breach).[12] Sediment relocation and deposition is expected to occur within the Federal navigation channel and on the left bank of Lake Wallulla. Additional dredging by the Corps would be required to maintain the Federal navigation channel. Likewise, public and private port facilities both near the confluence of the lower Snake River and on the left bank of Lake Wallula would be required to dredge in order to avoid interruptions in service and maintain access to the navigation channel. Estimated dredging costs for maintaining the Federal navigation channel would be a Corps' expense, while dredging costs to maintain port facilities and access to the Federal navigation channel would be a local municipalities and/or private business cost.

Dredging estimates were developed for the McNary pool based on the river mechanics analysis results. The first year post dam breach, it is estimated that 3.8 MCY would be dredged to maintain the Federal navigation channel, followed by 1.9 MCY annually for the next 3 years (years 3 through 6 post dam breach). As described above, by around year 7 a new system equilibrium would be reached and the passing of major sediment loads would decline. Beginning in year 7, maintenance dredging of 0.25 MCY annually would be expected. Based on these sediment estimates, total dredging costs for the first 5 years is approximately $108.7 million. Over the 50-year period of analysis annualized dredging costs are $6.1 million (annual equivalent dollars).

Dredging estimates were also developed for the potential dredging costs that would be incurred by others in order to access the Federal navigation channel. These include local port facilities and/or private terminals that would require dredging to reestablish service under 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.

MCY for the next 4 years. The total dredging costs for the first 5 years post dam breach, are approximately $143.1 million.

Dredging operations are expected to remain similar to the No Action in other reaches of the Columbia navigation channel, with an estimated cost of $67.1 million annually. In total, annual dredging costs would increase about 4.4 percent under MO3, from $70.1 million annually to $73.2 million.

**Commercial Cruise Line Operations**

As discussed in the No Action Alternative, approximately 18,000 visitors travel via cruise line along the lower Snake and Columbia Rivers each year. While it is uncertain how the cruise lines would respond to closure of the lower Snake River to navigation, it is clear that one of the primary draws of the trips are to see the Snake River. Given this, a substantial portion of these trips may be lost under MO3. For most of the typical 7-day cruise line trips, seven of the eight ports of call are in Region D, while one is located in Region C. Business revenues for cruise ship companies and ports where the vessels call between Astoria, Oregon, and Clarkston, Washington, would likely be adversely affected under MO3. Total estimated annual expenditures by approximately 18,000 cruise line passengers per year traveling on the lower Columbia and Snake Rivers is estimated to be $15.6 million annually. Impacts associated with reduced expenditures on commercial ferry trips are discussed in the Regional Economic Effects section.

**Commercial Ferry Operations**

The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under MO3 in average water years as well as in dry water years, similar to the No Action Alternative. In larger runoff years, the ferry would be inoperable for certain periods when Lake Roosevelt is lowered in April and May in order to reduce potential flooding effects downstream. In these higher water years, defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam, the Inchelium-Gifford Ferry would not be able to operate for approximately 29 consecutive days in the year under MO3 (or about 8 percent of the year in wet years), which is 2 days more than under the No Action Alternative (representing a 7.4% increase in the number inoperable days from the No Action Alternative). This would result from changes in operations at Grand Coulee Dam under this alternative.[13] The average daily number of passengers on the ferry is approximately 410. (CTCR 2019). At this rate, approximately 820 ferry trips could be affected in wet years by under MO3. Longer inoperable 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

## REGIONAL ECONOMIC EFFECTS

### Commercial Navigation and Transportation Systems

As discussed above, MO3 would necessitate changing the mode of transit for commodities that would have used the lower Snake River portion of the CSNS under the No Action Alternative. Changing the mode of transportation for these goods from commercial barge to road or rail would have regional economic implications. This section discusses potential regional economic effects associated with increased costs to the agriculture industry; increased demands for infrastructure, including highways, rail lines, grain elevators; impacts to port facilities and barge companies; impacts to support industries for the commercial cruise lines; and other city and local implications.

### Costs to Agricultural Operations

The entities producing and shipping goods on the CSNS would also experience increased costs under MO3. While the increased expenditures to transport goods would benefit, to some degree, the road and rail industries and industries that support them, producers of commodities would need to absorb the cost increase in their operations. As described above, costs to farmers are likely to vary based on location.

In order to illustrate how specific geographic locations would differ in terms of impacts of MO3, two hypothetical farmers were evaluated to illustrate how M03 would affect their shipping choices and costs related to the scenarios provided above. The first example evaluates impacts to a farmer that is located near Colfax, Washington, and one farmer is located near Grangeville, Idaho.

Example 1: Farmer Near Colfax with Many Shipping Options

The first example evaluates impacts to a farmer that is located near Colfax, Washington. The Colfax farmer is located in an area where there is intense wheat production and where there are several different choices for shipping wheat to market. Under the No Action Alternative, the Colfax farmer would ship wheat using the least-cost option available, which would be to truck grain to the port at Almota on the lower Snake River at a cost of 23 cents per bushel. (Figure X) Once at the port of Almota, the barge rate to ship the wheat to Portland would be 46 cents per bushel, for a total shipping cost of 69 cents per bushel.

Under MO3, where the option to utilize the lower Snake River for shipping would not be available, the Colfax farmer would choose the next cheapest option, which would be to ship wheat north to the McCoy shuttle rail facility at a cost of 21 cents per bushel (Figure Y). The Colfax farmer would then pay 51 cents per bushel to ship the wheat directly to Portland via rail for a total cost of 72 cents per bushel. As such, under Scenario 1, the No Rail Rate Increase Scenario, the farmer’s costs would increase by 3 cents per bushel (4 percent).

If the shuttle rail facility raises the rail rate by 25 percent from the No Action Alternative (Scenario 2), the Colfax farmer would continue to utilize the McCoy shuttle rate facility option, (Figure Y) but shipping costs would increase from 72 cents per bushel to 85 cents per bushel (21 cents from the truck travel to the shuttle rail and then 64 cents per bushel rail rate), which would represent an increase of 23 percent.

If shuttle rail facility raises the rail rate by 50 percent from the No Action Alternative, the Colfax farmer's next cheapest option would be to utilize the Lacrosse shuttle rail facility, which would increase shipping costs to $1.07 per bushel (35 cents truck cost to Lacrosse and 72 cents per bushel shuttle rail), which would represent an increase of 55 percent (Figure Z).

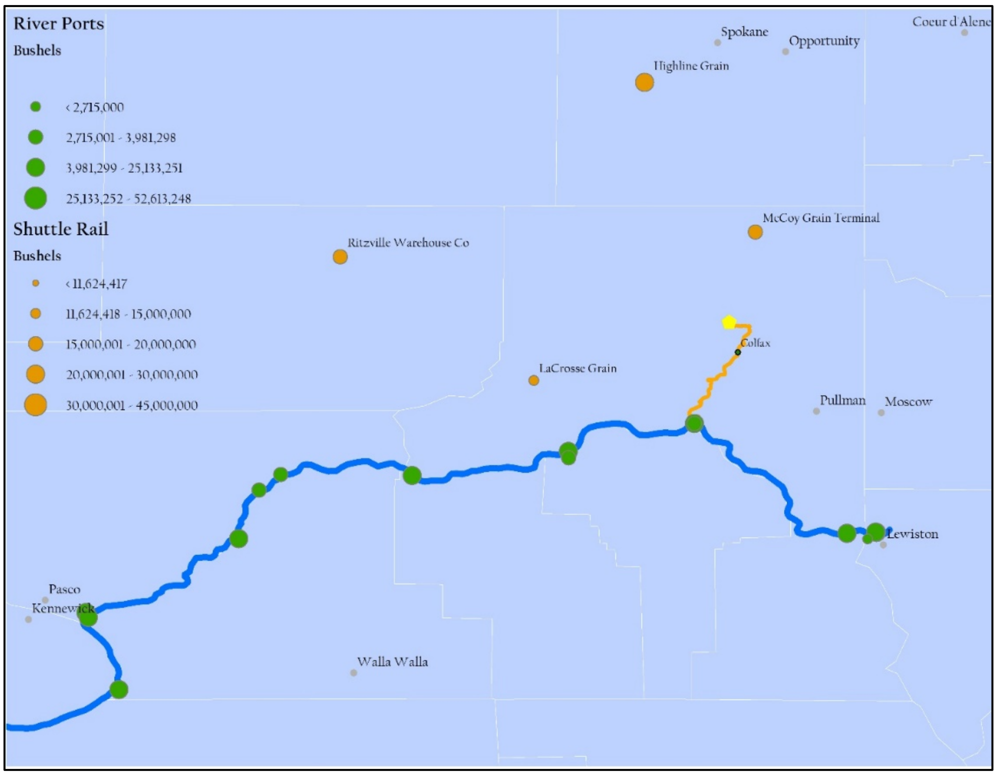
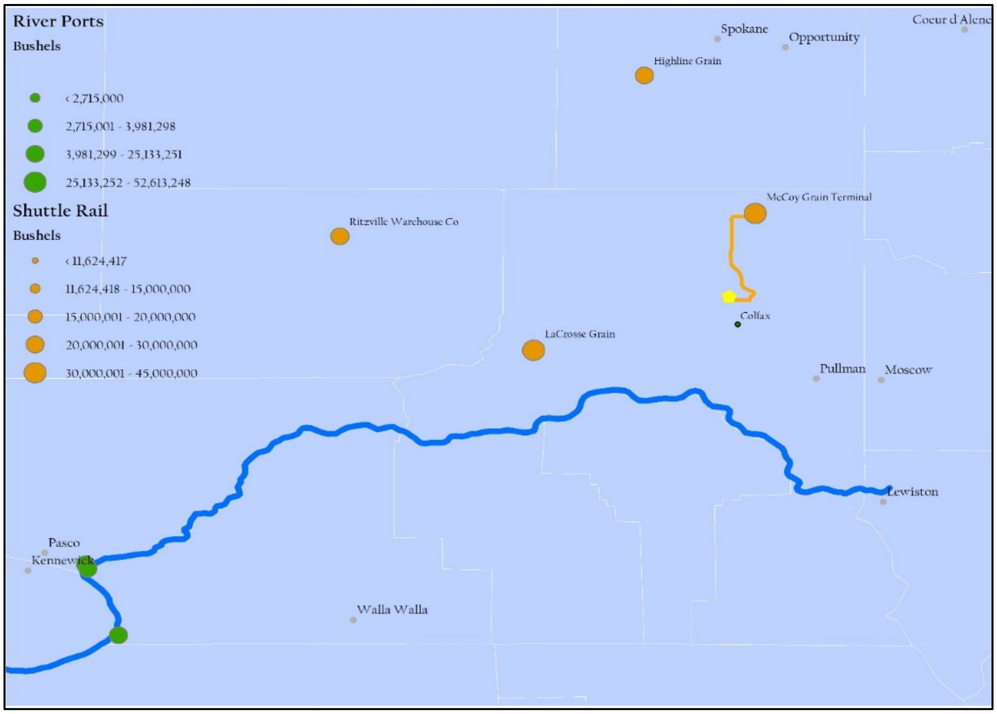


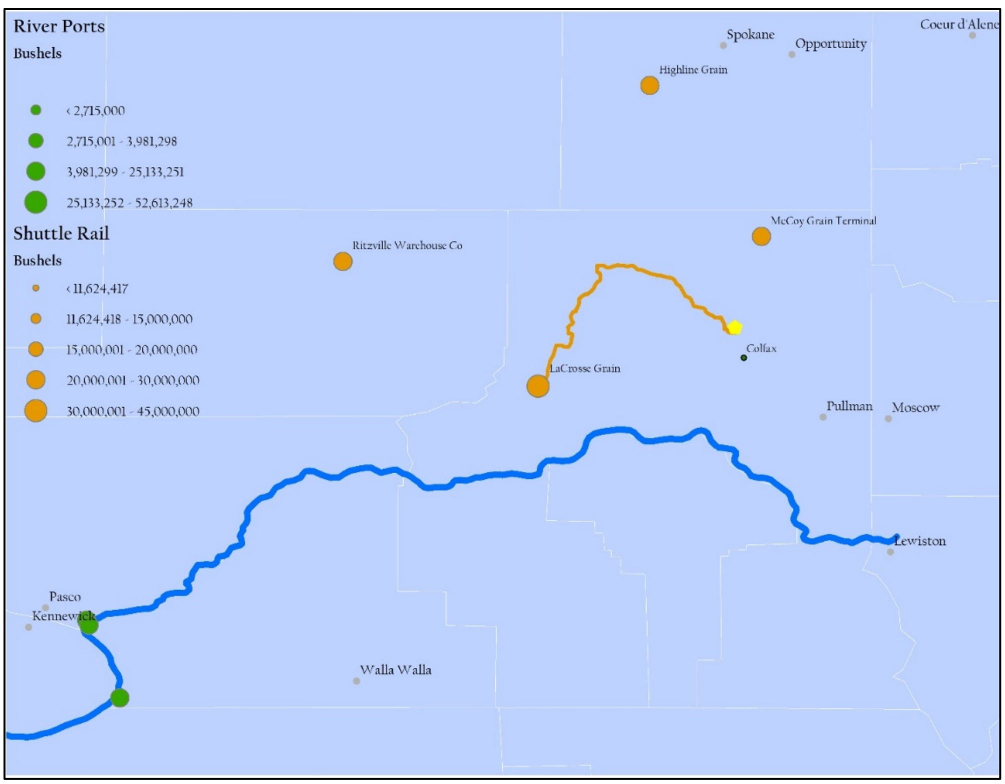

**Figure 3-215. Colfax-Area Farmer Transit Route Under the No Action Scenario**

A second example evaluates impacts to a farmer that is located near Grangeville, Idaho. A farmer in Grangeville is located at the edge of wheat production in the Northwest and has relatively limited shipping options. Under the No Action Alternative, the Grangeville farmer's least-cost option would be to truck wheat from the farm to the Lewiston barge terminal at a cost of 47 cents per bushel and then pay another 47 cents per bushel barge rate to move the grain to Portland for a total cost of 94 cents per bushel (Figure XX). As such, shipping costs are approximately 36 percent higher than the Colfax farmer's shipping costs under the No Action 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

Under MO3 when river barge is not available on the lower Snake River, the Grangeville farmer's next-best option would be to truck the wheat from the farm to the McCoy shuttle terminal at a cost of 75 cents per bushel and then to pay the 51 cents per bushel to ship the wheat via rail to Portland, for a total cost of $1.26 per bushel. As such, under Scenario 1, the No Rail Rate Increase Scenario, costs would increase by 32 cents per bushel (34 percent).

If the railroads begin raising rates by 25 percent or 50 percent (Scenarios 2 and 3), the Grangeville farmer would be better off trucking the grain all the way to the Tri-Cities for a cost of $1.08 per bushel and then paying 36 cents per bushel to barge the grain to Portland at a total cost of $1.44 per bushel. As such, under Scenarios 2 and 3, costs would increase by 50 cents per bushel (53 percent).

The difference between the Grangeville farmer and the Colfax farmer is that the Grangeville farmer has higher transportation costs to begin with given that he is much farther from market and has limited transportation options in order gain access to those markets. Once those options are reduced, as would occur under MO3, the Grangeville farmer cost impacts would be much greater. Under MO3 when rail rates increase by 50 percent, the Grangeville farmer's costs would increase by 50 cents per bushel, compared with 39 cents per bushel for the Colfax farmer, both representing an increase in shipping costs of over 50 percent compared to the No Action Alternative.


**Figure 3-218. Grangeville-Area Farmer Transit Route Under the No Action Alternative**

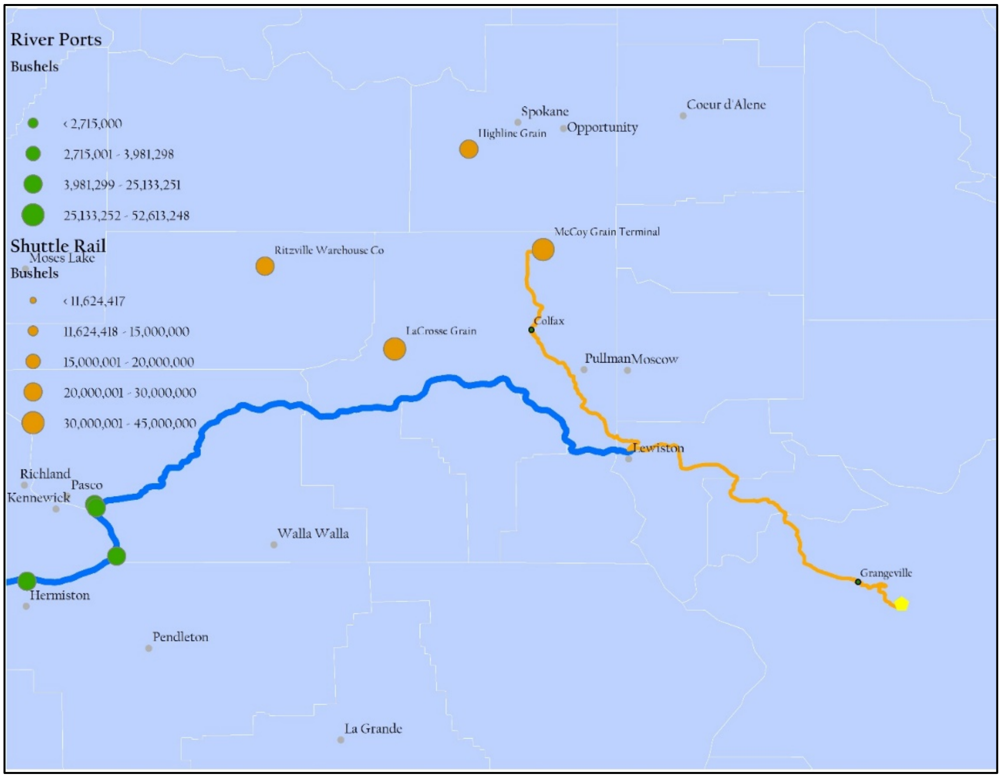



**Figure 3-219. Grangeville-Area Farmer Transit Route Under Scenario 1: No Rail Rate Increase**

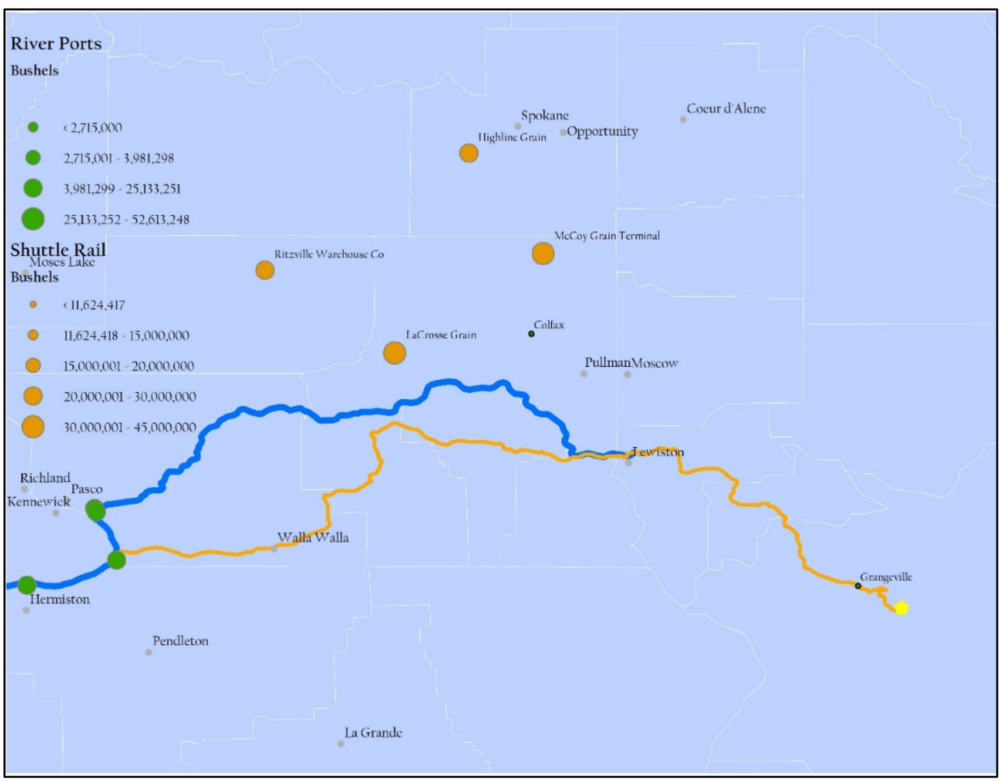



**Figure 3-220. Grangeville-Area Farmer Transit Route Under Scenarios 2 and 3: 25% and 50% Rate Increase**

Faced with increasing transportation costs of over 50 percent, profitability of farming in this region would be adversely affected. However, the analysis indicates the cost to transport wheat to market would still be less than costs paid by other wheat growers in the United States (e.g., the Dakotas and Midwest). For example, with the current total cost of producing wheat being approximately $6 per bushel, the estimated cost increase of $0.07 (average increase under Scenario 1) to $0.50 per bushel (for Grangeville farmer under Scenario 2 or 3) would represent a 1 to 8 percent increase in total production costs, marginally affecting competitiveness (Figure ZZ). The wheat grown in the Northwest is soft white wheat. This type of wheat is a preferred grain for Asian and Eastern countries; however, there is no guarantee wheat grown in the Northwest will be competitive now or in the future because there are so many factors that influence international commodity markets (e.g., trade agreements, the U.S. dollar, global supply, etc.). In general, wheat producers are 'price takers,' so keeping production costs lower are critical for remaining competitive. Favorable conditions for Northwest wheat growers that help them stay competitive are: (1) the natural environment of the Palouse region (weather, soils) is ideal for growing this type of wheat, which leads to some of the highest yields per acre in the world, and (2) proximity of Northwest export ports. Currently, the cost to transport wheat to market is quite low relative to other parts of the United States and world.

***Infrastructure Costs***

With dam breaching and a shift of commodities from shipment on the lower Snake River to other shipping modes, demands for the region's land-based transportation and grain handling infrastructure would increase. These increases in infrastructure demands could vary widely depending on factors such as the changes in rail rates, which influence the mix of alternative transportation modes that are utilized. In our scenarios, the largest demands on rail would occur under Scenario 1, when rail rates are assumed not to increase and rail transit would be relatively more attractive. In contrast, increased highway use would be highest under Scenario 3, when rail rates are assumed to increase by 50 percent.

This section addresses impacts to the rail system, potential effects to rail car demands, highway system requirements, and grain elevator capacity requirements that may occur under the various scenarios, as well as potential costs associated with these demands. Estimates were developed for these costs based on input from local stakeholders, as well as published reports including the 2002 Lower Snake River Feasibility Study/EIS (2002 EIS), and the 1999 Lund Report. Both of these studies considered infrastructure investments that would be needed if the lower Snake River dams were breached.

It should be noted that the high rail demand scenario and the high highway demand scenario would not both occur. In addition, infrastructure investments are transitional costs, and would primarily be borne by private entities, including rail lines and grain shippers. Over time, prices should adjust to cover these costs. Some highway costs would be transferred to the trucking industry through fees, though most costs would likely be borne by public entities. Because of the high level of uncertainty surrounding these costs, interpretation should be done with caution.

Highways and Highway Congestion

Transportation officials and regional policy planners are often concerned with how closure (or opening) of one mode option impacts truck traffic and ultimately impacts the highway system. The comparisons between how each of the TOM scenario results in impacts on the public highway system is best captured in comparing the ton-miles between different origin-destination types in each scenario. The ton-mile more accurately captures the comparison in volume and distance across different freight modes. But often planners are also concerned with absolute number of truck trips. These comparisons may also be made utilizing the same tables and dividing the total volume (bushels) for each truck origin-destination type by 1,000 (the approximate capacity of the typical grain truck). Depending on the scenario, truck ton-miles may experience an increase of 19 percent under Scenario 1, when rail rates are not assumed to increase, to 84 percent when rail rates increase by 50 percent under MO3, when compared to the No Action Alternative. Since the TOM captures all grain movements leaving the farm, the total number of trucks for shipments leaving the farm doesn’t change between each scenario given that total grain production would not be anticipated to change. But the distribution of shipments and truck trips to the various destinations after leaving the farm does change once the choice set changes. The most immediate and noticeable impact comparing the No Action Alternative to MO3 is that the number of truck trips going to the river ports decreases by 80,086 trucks as farmers now choose the next least-cost option, which would be shuttle rail under Scenario 1. That would result in an additional 46,638 trucks going from the farm to elevators with rail access instead and an additional 32,495 trucks to elevators with rail access and an additional 892 trucks going from the farm to elevators without rail access. Also, under Scenario 1, an additional 498 truck trips would occur for trans-shipments between elevators without rail to those with rail that didn’t occur under the No Action Alternative. The net additional trips under Scenario 1 is 13,515 truck trips compared to the No Action Alternative.

Once railroads increase rail rates by 25 percent under Scenario 2, truck trips to the remaining Columbia River ports would become more attractive (compared to shuttle rail with higher rates) and shippers would begin to increase truck trips to those ports as elevator (both with and without rail access) to river port truck shipments increase. The total net additional trips under this scenario would be 32,249 truck trips compared to the No Action Alternative, with an additional 25,711 truck trips due to elevator to river port shipments. Truck shipments to shuttle elevators would decline under Scenario 2 compared Scenario 1, but would still be higher than under the No Action Alternative.

Once railroads increase rail rates by 50 percent, the net additional trips would increase to 79,250 truck trips compared the No Action Alternative, with the majority of that coming from elevator to river port movements.

Changes that would result in increased truck usage would also add to vehicular traffic and congestion. As shown in Figure 3-208 (Scenario 2 map), Highway 12 and Highway 395 appear likely to experience increases in traffic. These, in turn, would have impacts on infrastructure costs. In particular, the costs to maintain roadways may increase under MO3. Using estimates of road resurfacing costs in eastern Washington per ton-mile from published literature of $0.01 (state roads) to $0.04 per ton-mile (county roads). Based on likely route patterns, it was assumed that 60 percent of increased traffic would occur on state roads and 40 percent would occur on county roads. Under Scenario 1, costs to maintain the roads due to the increased truck traffic would be approximately $2 million annually. Under Scenario 2, where truck use would increase moderately, increased pavement damage costs would be approximately $4 million annually. Under Scenario 3, where truck use would increase most substantially, increased pavement damage costs would be approximately $10 million annually.

<u>Rail Lines and Demand for Rail Cars</u>

Depending on the price increases by rail lines under MO3, rail traffic would be anticipated to increase when compared to the No Action Alternative when barges would share the transportation load. The higher the increase in rail prices, the lower the increased demand for rail (this is because other options, such as transit via truck to the Tri-Cities area, would be relatively more affordable as rail prices increase). Rail ton-miles may increase by as much as 86 percent under Scenario 1, when rail rates are not assumed to increase, or by 63 percent under Scenario 2 (25 percent rail rate increase). Under Scenario 3, with a 50 percent rail rate increase, rail ton-miles would be anticipated to decrease by 2 percent (under Scenario 3). As such, although Scenario 1 may be the most unlikely, it also defines the highest increase in demand for rail.

*Increased capacity at shuttle rail facilities*. As discussed in the social welfare section, the increase in rail demand under Scenario 1 (no rail rate increase) and Scenario 2 (25 percent rail rate increase) would represent an increase in the demand for shuttle rail capacity that would exceed current shuttle rail capacity. Increased capacity needs would range from approximately 38 million bushels under Scenario 1 (approximately the size of one shuttle rail facility) to 19 million bushels under Scenario 1 (less than one shuttle rail facility). Increased shuttle rail capacity would not be required under Scenario 3. Costs to develop this increased capacity would vary depending on the type of storage provided. Increased investments at ports around the Port of Pasco would also likely be required. Based on input from local shuttle rail facility operators, the cost to construct a new shuttle rail facility with the ability to move 25 million bushels of wheat/barley per year is approximately 25 million per year. Based on this it is estimated that one to two shuttle rail facilities could be needed at a cost of $25 to $50 million.[14]

*Demand for trains and rail cars***.** As discussed in the social welfare effects section, the number of unit trains (with approximately 110 cars per train) would be anticipated to increase under Scenario 1 (no rail rate increase) from approximately four trains to approximately eight trains 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.

region would increase by 185 annually, and the number of shuttle rail cars loaded would increase by over 20,000 under Scenario 1. This would represent an increase of 94 percent over current shuttle rail activity. Scenario 2 also anticipates increased demands are somewhat lower, at 133 trains and 14,600 rail cars. Similarly, the 2002 EIS found the unavailability of variable inputs, such as locomotives, rail cars, and train crews could lead to serious short-turn capacity constraints for mainline rail lines. However, in the long run, these services would be acquired "at prices that would not affect rail rates if rail carriers face effective competition in rail-served markets" (2002 EIS, Appendix I).

*Costs to improve condition of shortline rail*. Local stakeholders as well as WSDOT stated that the shortline rail lines are in need of improvement, and would require significant investment to handle higher volumes. Similarly, the 2002 EIS found that shortline rail lines were in generally poor condition at the time. These rail lines were characterized as "spin-offs of low volume, low revenue/profit segments of the mainline system and maintenance tends to be deferred. Needed improvements included interchanges with mainline railroads, track upgrading, and other. Costs of shortline rail improvements were estimated to range from $30 million to $36 million or $2.1 million to $2.5 million annualized over 50 years (inflated to 2019 dollars). These would be generally private investments, although public investments of the PCC could also be required.

*Congestion on mainline rail lines*. Concerns have been raised about congestion on the mainline rail lines; however, based on available information congestion and associated capacity constraints are likely more associated with shuttle rail facilities and/or shortline rail upgrades. Similarly, the 2002 EIS found that diversion of lower Snake River traffic to rail lines would increase rail traffic, but would not create substantial capacity issues along the mainline rail corridor. Even though some congestion was expected, the 2002 EIS found that BNSF and UP would be able to address capacity issues without increasing long-term marginal costs or changing rates. When the EIS 2002 interviewed a representative at BNSF, BNSF asserted that existing rail capacity would sufficient to handle the increase in traffic with dam breaching (2002 EIS, Appendix I).

***Effects to Ports and Barge/Towboat Companies***

The analysis finds that under Scenario 1, barge volume would decrease by 64 percent on the system relative to the No Action Alternative (some volume would continue to transit the Columbia River below the breached dams). Under Scenario 2, barge traffic would also decrease by 52 percent. Reductions would be less under Scenario 3, when rail rates are the highest, when barge volumes would be reduced by 22 percent. A change in transportation mode away from barge would affect regional businesses that support port and barge activities as well as associated employment opportunities, particularly in the short term, as businesses adjust to the new shipping conditions and employment demands. Under this scenario, adverse effects to companies reliant on barge transit, such as towing companies, could be adversely affected. As discussed in Section 3.10.2, *Affected Environment*, a small number of companies specialize in operating barges and tow boats on the CSNS. These operators employ approximately 450 employees, which range from captains and crews to tugboat operators, shipping handlers, to boat builders. Many crew members permanently reside in the greater Portland area, but some reside in upriver areas (Tidewater Barge Lines 2020; Shaver Transportation Company 2020). The commercial navigation industry supports employment for a wide range of transportation and material moving occupations. Some of these positions, such as material moving workers, including freight, stock, and material movers, may be readily transferable to support for road or rail transportation activities, while others, such as boat captains, pilots and operators, and ship engineers, would not be transferable, and could result in relocation of some workers to areas downstream or to other professions not dependent on river navigation. These companies report that many of their employees are long term, having niche experience and skills that would likely be difficult to transfer to other industries. (Tidewater Barge Lines 2020; Shaver Transportation Company 2020). They also report that approximately 50 percent of their business is conducted on the lower Snake River, and surmise that removal of the ability to utilize the river could threaten their ability to maintain profitability.

Increased demand for rail operators as well as for truck transport and support services would increase under this alternative. Industry representatives have noted that an increased demand for trucking services would likely result in a shortage in the availability of trucks drivers in the short term (Port of Lewiston and industry stakeholders 2019).

**Commercial Cruise Line Operations**

Total estimated annual expenditures by approximately 18,000 cruise line passengers per year traveling on the lower Columbia and Snake Rivers is estimated to be $15.6 million annually under the No Action Alternative. As discussed in the No Action Alternative section, this assumes that passengers would typically spend 7 days on the Columbia and Snake Rivers, and would spend approximately $124 per day in the region (Port of Lewiston/Shoreline Excursions 2019). These expenditures would create demand for approximately 230 jobs in the region, and would generate $6.2 million in labor income, and $17.8 million in output (sales). Most of these effects would be in Region C, with remaining expenditures in Region D. This is because most of time on cruises is spent in upriver areas. While it is uncertain how the cruise lines would respond to closure of the lower Snake River to navigation under MO3, it is clear that one of the primary draws of the trips are to visit the lower Snake River areas in Regions C and D. Given this, a substantial portion of these trips and the expenditures associated with them may be lost under MO3. To the extent that visitors no longer visit the lower Snake River, these expenditures would be lost to that area. The areas around ports of call, and particularly Lewiston, Idaho, and Clarkston, Washington, which are the final destination points for typical cruise line visitors and where more time is typically spent by passengers, could experience the most changes in regional tourist expenditures associated with these changes. However, economic losses would be experienced along the route at ports of call from Astoria, Oregon to Lewiston, Idaho.

**Commercial Ferry Operations**

The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under MO3 in average water years as well as in dry water years. The Inchelium-Gifford Ferry would not be able to operate for approximately 29 consecutive days in the year under MO3 (or 8 percent of the year) in wet years, which is 2 days more than under the No Action Alternative (representing a 7.4 percent increase in the number inoperable days from the No Action Alternative). Longer inoperable periods would be expected in wetter years that require more FRM space. In those years and for those days, expenditures associated with these trips via ferry would likely be delayed or would not take place in the same locations.

**City/Local Effects Associated with Changes in Commercial Navigation, Cruise Lines, and Ferry Operations**

Cities and towns provide labor and services to the commercial navigation industry. When shipping modes shift away from barge, cities and towns that provide services to the industry will be affected.

One method to capture the overall regional economic effects associated with shipping cost increases to the agriculture industry is to assume that increased transportation costs would result in decreased profitability of grain production, which would manifest itself in reduced local expenditures and investments, including some reduced labor demand. By assuming the lost profitability would be reflected in lost farm revenues, this analysis can provide an approximate estimate of regional effects of transportation cost increases.

Using this method, increased shipping costs (assumed to represent reductions in farm income) of $159 to $192 million would be estimated to result in a reduction in demand for employment of 116 to 402 jobs, and may result in reductions of regional economic output of $22 million to $77 million (CRSO EIS IMPLAN analysis 2020). This estimate does not include potential impacts associated with reduced demand for barge employment or an increased demand for trucking employment that would accompany these shifts.

Because trucking is more labor intensive than barge operations, increased trucking demand would likely increase employment demand for shipping handlers. However, stakeholders have noted that, in the short term, an already tight market for truck drivers would be made even tighter.

Further, the estimate of employment effects does not consider additional changes in employment demand that may occur associated with industries that depend on river navigation other than agriculture. These include industries that rely on the river for inputs or for discharges, such as the large papermill in Lewiston, Idaho, that utilizes barges to provide wood chips to the facility (City Manager of Lewiston, Idaho 2019; Clearwater Paper 2020). City managers in towns along the river are also concerned about less direct effects of dam breach, including reduced appeal of the area for aluminum boat building, which has located in the Lewiston and Clarkston areas (City Manager of Lewiston, Idaho 2019; Mayors of Asotin, Washington and Clarkston, Washington 2019).

In addition to a loss of navigation on the rivers, upriver communities on the lower Snake River are concerned about the loss of tourists that currently visit the areas via cruise ships, as discussed above.

## OTHER SOCIAL EFFECTS

### Commercial Navigation and Transportation Systems

As noted, the navigation channel on the lower Snake River would become inoperable under MO3, resulting in substantial changes to port operations. This would affect approximately 14 river terminals on the lower Snake River. Some terminals would likely transition from being water-based to other modes; other terminals could close. These structural changes to the economic base would affect regional demand for some labor categories and could affect commuting patterns as well as housing demand. The loss or transition of port operations in some communities could also result in community-level effects associated with changes in the character of the communities and community identity from communities that have evolved to depend on reservoir conditions to communities more reliant on river and perhaps land-based recreation and other services.

As discussed above, depending on the scenario, truck ton-miles may experience an increase of 19 percent (under Scenario 1, when rail rates are not assumed to increase) to 84 percent (when rail rates increase by 50 percent) under MO3 when compared to the No Action Alternative. Rail ton-miles may increase by as much as 86 percent (under Scenario 1, when rail rates are not assumed to increase) or decrease by 2 percent (under Scenario 2, when rail rates increase by 50 percent). As discussed in Section 3.8, *Air Quality and Greenhouse Gases,* these modal transportation changes would likely lead to an increase in air pollutant emissions, specifically HAPs, VOCs, CO, PM, and $NO_x$, from rail and truck transportation, under MO3 relative to the No Action Alternative. These air pollutants have a variety of adverse health and environmental effects including respiratory health effects. In addition, many of these air pollutants react in the atmosphere to form ozone as well as haze, which can negatively affect regional visibility, particularly in national parks and scenic areas such as the Columbia River Gorge Scenic Area. Regional haze is a key concern in these areas as it creates visibility issues that affect recreational and scenic value. Air quality studies of the Gorge Scenic Area identified on-road vehicles as a source of the regional haze (ODEQ 2011). See Section 3.8 and Chapter G-4 of Appendix G for additional details on regional haze and the air quality analysis.

Greenhouse gas emissions would also increase under MO3 compared to the No Action Alternative since rail and truck transportation generate more carbon dioxide ($CO_2$) per ton-mile of freight compared to barge transportation. Specifically, truck transportation can emit nearly 10 times more $CO_2$ per ton-mile than inland barges. As a result, decreases in barge transportation and increases in truck and rail transportation under MO3 would result in an increase in $CO_2$ emissions of up to 30 percent. Table 3-247 summarizes the carbon dioxide emissions by mode and the difference from No Action Alternative. Section 3.8 discusses the air quality and greenhouse gases analysis further.

**Table 3-247. Navigation $CO_2$ Emissions by Type under Multiple Objective Alternative 3 and No 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 |

Changes in transportation modes would also have implications for public safety. As noted in Section 3.10.3.1, *Methodology*, accident rates are generally higher for road travel than travel by either barge or rail (Inland Rivers Ports & Terminals, Inc. 2019). As such, accident rates would be expected to increase under MO3.

**Commercial Cruise Line Operations**

As discussed above, it is uncertain how the cruise lines would respond to closure of the Snake River to navigation under MO3. However, it is clear that one of the primary draws of the cruise line trips are visits to the Snake River areas in Region C. Given this, a substantial portion of these trips and the expenditures associated with them may be lost under MO3 when that area would be rendered inaccessible to navigation. To the extent visitors would no longer visit the Snake River, these expenditures would be lost to the Snake River port areas where the cruise lines would have docked. The areas around ports of call, and particularly Portland, Oregon, which is the typical departure point for cruise line visitors, as well as Lewiston, Idaho, and Clarkston, Washington, which are the most common final destination points for cruise line visitors, could experience the most reduction in regional tourist expenditures associated with these changes. Tourism businesses could be adversely affected by these changes in expenditures, which could be more apparent in rural areas, such as near the Port of Benton, where local economies are more dependent on these expenditures, than larger urban areas.

**Commercial Ferry Operations**

The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under MO3 in average water years as well as in dry water years. MO3 would result in a loss of 2 additional days of operations by the Inchelium-Gifford Ferry in wet years for a total of 29 consecutive days without ferry operations. Longer inoperable periods would be expected under more extreme high-water years. In those years and for those days, travel from remote communities that use the ferry would not be possible**.** Changes in access for the remote communities during those days would reduce access to healthcare and educational facilities, in addition to food and shopping resources. Without the ferry, commuters and others who need to make the trip must take a 70-mile detour, which adds substantial mileage, gas costs, time, air emissions, and other effects (Spokesman-Review 2017). Since the ferry is free and reduces driving time and distance, the loss of ferry service will create additional transportation costs.

**SUMMARY OF EFFECTS - MULTIPLE OBJECTIVE ALTERNATIVE 3**

Major adverse effects would be anticipated under MO3 as commercial navigation on the lower Snake Shallow section would effectively be eliminated. In addition, the area at the confluence of the lower Snake River with the Columbia River and within the McNary Reservoir would have increased sedimentation for approximately 2 to 7 years following dam breach, when sedimentation rates are anticipated to stabilize. Grain shippers, who are the primary shippers in the lower Snake River, would face increased regionwide transportation costs over the short and long term that would range from $0.07 to $0.24 per bushel. Cost increases for 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) would be the most negatively impacted. Scenario 1 under MO3 anticipates a 10 percent increase in shipping costs for grain shippers. This scenario is heavily dependent on two assumptions: (1) the existing shuttle rail facilities are able to accommodate most of the grain that otherwise would have used the lower Snake River ports (slightly more than double existing shuttle rail facility volumes) and (2) the shortline railroads are able to accommodate increased volumes going to shuttle rail facilities. Under this scenario, increased rail demands would likely exceed current shortline rail capacity by 38 million bushels. This would likely require increased investments in shortline rail capacity to meet demand, with costs that could range from a total of $25 to $50 million, assuming new facilities would be required to accommodate the increase in capacity. In addition, upgrades to existing shortline rail lines of approximately $30 to $36 million, or approximately $2 million annually may be needed.

Under Scenario 2, there would be a 22 percent increase in total transportation costs regionwide. As under Scenario 1, increased rail demands would likely exceed current shortline rail capacity, but somewhat less than under Scenario 1 (19 million bushels). Costs to increase capacity could be as high as $25 million under this scenario. Truck use would moderately under Scenario 2, which would increase wear and tear on roadways and could result in additional road repair costs of up to $4 million annually.

Under MO3 Scenario 3, there would be a 33 percent increase in total transportation cost regionwide. However, some individual shippers may experience increases that are more than double this amount, depending on location. Under this scenario, truck use would substantially increase, which would result in increases in vehicular accident rates, highway traffic and congestion. In addition, additional wear and tear on roadways could result in additional road repair costs of up to $10 million annually. Columbia River navigation would continue to be important in the region below Pasco under MO3. Effects of these mode changes would be most acute in the short term. As the industry adapts over time, more rail capacity and associated storage would likely be added in the region to accommodate freight affected by loss of river navigation on the lower Snake River. In any of these scenarios, regional economic effects would occur as the jobs and income provided by the four primary commercial navigation ports would be curtailed, including the Port of Lewiston, the Port of Clarkston, the Port of Whitman County (Wilma, Almota, Central Ferry), and the Port of Garfield.

Cruise ship transit to the lower Snake River would not be possible. Given this, a substantial portion of cruise lines trips may be lost under MO3. This could represent a loss of up to 18,000 visitors and $15 million in direct expenditures per year.

MO3 would result in negligible to the operations of the Inchelium-Gifford Ferry, which would be precluded for 2 additional days under MO3 relative to the No Action Alternative in wet years (for a total inoperable period of 29 consecutive days) and could represent 820 fewer ferry trips. During those years negligible social welfare effects could be experienced due to the slightly longer inoperable period. Negligible effects due to loss or redistribution of expenditures associated with the ferry trips could also occur. Changes in access to healthcare and educational facilities, in addition to food and shopping resources could result in minor adverse effects. Other ferries would not be affected under M03.

Some tribes have commented that there are ongoing adverse 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, under all MOs. They note that these cumulative effects, along with impairment of Indian treaty-reserved rights, may be reduced under MO3 (Nez Perce Tribe 2020).

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. |

| 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. |

1/ “Wet” water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam.

### *3.10.3.6 Multiple Objective Alternative 4*

While a complete list of the measures employed for MO4 may be found in Chapter 2, this section focuses on measures that may affect navigation. A number of planned structural measures under MO4, such the addition of spillway notch weirs or modifying turbine intake bypass screens that cause juvenile lamprey impingement, are unlikely to have measurable impacts to navigation in the CSNS. The *Drawdown to MOP*, *Winter System FRM Space*, *Spring & Fall Transport* measures may change the costs for vessel movements on the CSNS by altering the quantity or the timing of the flows. The *Spill to 125% TDG* measure operations may increase shoaling in the navigation channel, affecting sediment accumulate. In addition to these measures, commercial ferry operations on Lake Roosevelt have the potential to be affected by operational measures at Grand Coulee that result in lower reservoir levels in the early spring (*Winter System FRM Space*, 0.8 foot SRD, etc.)

A few operational measures within MO4 such as conducting or ceasing juvenile fish transport will not physically affect flow levels, so they are not considered for this analysis. Operational measures that affect changes at Hungry Horse Reservoir, Chief Joseph Dam, Lake Roosevelt, or Grand Coulee Dam are assumed to not impact navigation due to the distance between these projects and the lower Columbia navigable channel.

**SOCIAL WELFARE EFFECTS**

**Commercial Navigation and Transportation Systems**

Table 3-249. shows the difference between MO4 and the No Action Alternative in terms of flow days. The H&H data used as input into the SCENT model shows that MO4 would have slightly fewer days in normal and high flow conditions and a greater number of days in the low category than the No Action Alternative. In both the shallow-draft and deep-draft segments of the river, there would be approximately 9 more days of average annual low flows under MO4 than under the No Action Alternative.

**Table 3-249. Changes in Average Commercial Navigation Flow Days Under Multiple Objective 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) |

Note: The “Shallow” category includes both the Columbia-Snake Shallow category, which refers to traffic that traveled on both the Columbia and Snake Rivers, and the Columbia Shallow, which presents the impact to traffic only traveling on the Columbia River.
Source: SCENT modeling.

Table 3-250. for MO4 shows the average annual costs associated with each river segment and the additional transportation costs for the various flow conditions and draft restrictions compared to the No Action Alternative. As shown, the difference between these two alternatives is small, which is consistent with the H&H data used as input into the SCENT.

As shown in Table 3-235., average annual extra transportation costs in the Columbia Shallow are estimated to be $15,000 less than the No Action Alternative under MO4. These effects are within one standard deviation of the No Action Alternative conditions. The average annual extra transportation costs for transportation in the deep-draft segment are estimated to be $300,000 more than the No Action Alternative under MO4 across the industry. These effects are slightly higher than one standard deviation above the No Action Alternative conditions. The $300,000 increase represents less than 0.1 percent of average annual industry operational costs.

**Table 3-250. Changes in Average Annual Costs of Operations Under Multiple Objective Alternative 4 Relative to No Action Alternative (2019 Dollars), 50 years**

| | Change in Costs Associated with Flow Range Categories | | | | Changes in Costs Associated with Draft Restrictions | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **River Segment** | **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** |

Note: These effects are all within one standard deviation of the current conditions. Costs of operations under normal flow range categories are not anticipated to be affected under any alternatives and are therefore excluded from the table.

Source: SCENT modeling

**Dredging Operations**

In Regions C and D, increased spill operations from the *Spill to 125% TDG* measure combined with lower tail water would increase shoaling in the navigation channel at John Day, McNary, Ice Harbor, Lower Monument and Lower Granite. These effects are not calculated as part of the transportation cost impact, but instead are estimated based on the River Mechanics analysis, along with input from operations and cost engineering.

However, in order to avoid or reduce potential adverse impacts to commercial navigation to negligible impacts, MO4 would result in some additional needs for dredging in the lower Snake and Columbia Rivers. Over a 50-year period of analysis, annualized dredging costs would increase by $1.03 million annually. This is equal to a 1.01 percent increase in annual dredging costs.

**Commercial Cruise Line Operations**

No changes to cruise ship operations would occur under MO4 because anticipated changes to river flows and stages would not affect timing or use of the navigation channel.

**Commercial Ferry Operations**

The H&H modeling data indicate that water surface elevations on Lake Roosevelt would be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under MO4 in average water years as well as in dry water years. In larger runoff years, the ferry would be inoperable for certain periods when Lake Roosevelt is drafted deeper in April and May as planned under *Planned Draft Rate at Grand Coulee* and *Updated System FRM Calculation* measures. These measures would be used to reduce potential flooding effects downstream, similar to the No Action Alternative. In these "wet" water years, defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam, the Inchelium-Gifford Ferry would not be able to operate for approximately 36 consecutive days in the year under MO4, which is 9 days more than under the No Action Alternative (a 33 percent increase). Longer inoperable periods would be expected in wetter years that require more FRM space. This would result from changes in operations at Grand Coulee Dam under this alternative.

**REGIONAL ECONOMIC EFFECTS**

**Commercial Navigation and Transportation Systems**

Average annual costs to the navigation industry would increase by approximately $300,000 under MO4. These effects are not likely to result in noticeable effects to regional economies because they would be distributed throughout the industry, where this increase represents less than 0.1 percent of normal operating costs.

**Commercial Cruise Line Operations**

Negligible effects to commercial cruise line operations would occur under MO4. Given this, effects to regional economies are not anticipated.

**Commercial Ferry Operations**

The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under MO4 in average water years as well as in dry water years. MO4 would result in a loss of 9 additional days of operations by the Inchelium-Gifford Ferry in wet years (a 33 percent increase compared to the No Action Alternative), which could represent 3,700 fewer ferry trips. Longer inoperable periods would be expected in wetter years that require more FRM space. In those years for those days, expenditures associated with these trips via ferry would likely be delayed or would not take place in the same locations.

**OTHER SOCIAL EFFECTS**

**Commercial Navigation and Transportation Systems**

Average annual costs to the navigation industry would increase by approximately $300,000 under MO4. These effects are not likely to result in noticeable changes to other social effects, including changes in air emissions, accident rates, or changes in infrastructure costs under MO4.

**Commercial Cruise Line Operations**

Negligible effects to commercial cruise line operations would occur under MO4. Given this, changes to other social effects are not anticipated under MO4.

**Commercial Ferry Operations**

The H&H modeling data indicates that water surface elevations on Lake Roosevelt in Region B would continue to be sufficient to allow operation of the Inchelium-Gifford Ferry every day out of the year under MO4 in average water years as well as in wet years. MO4 would result in a loss of 9 additional days of operations by the Inchelium-Gifford Ferry in wet years (a 33 percent increase compared to the No Action Alternative). Longer inoperable periods would be expected in wetter years that require more FRM space. In those years and for those days, travel from remote communities that use the ferry would not be able to occur. Changes in access by the remote communities during those days would reduce access to healthcare and educational facilities, in addition to food and shopping resources. Without the ferry, commuters and others who need to make the trip must take a 70-mile detour, which adds substantial mileage, gas costs, time, air emissions, and other effects (Spokesman-Review 2017). Since the ferry is free and reduces driving time and distance, the loss of ferry service will create additional transportation costs.

## SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 4

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. The increase in costs for deep-draft navigation would result from additional days of low flows requiring an increase in the number of tug operations. Overall, this would represent an increase in average annual costs of $300,000 to the industry, representing a less than 0.1 percent increase in costs in comparison to the No Action Alternative. Effects to the cruise line industry would be negligible.

The Inchelium-Gifford Ferry would be able to operate 9 days fewer under MO4 than under the No Action Alternative in wet years, which could represent 3,700 fewer ferry trips. Longer inoperable periods would be expected in wetter years that require more FRM space. During those years, minor social welfare effects could be experienced due to the longer inoperable period. Minor effects due to loss or redistribution of expenditures associated with the ferry trips could also occur. Changes in access to healthcare and educational facilities, in addition to food and shopping resources could result in moderate adverse effects. Other ferries would not be affected under MO4.

Other than the ferry effects in wet years, effects to commercial navigation and transportation systems under MO4 are anticipated to be negligible over the short and long term when compared to the No Action Alternative. Table 3-251. provides a summary of the navigation and transportation system effects of MO4.

**Table 3-251. Changes in Costs of Commercial Navigation Operations Under Multiple Objective 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. |

1/ "Wet" water years are defined as conditions under the highest 20th percentile forecasted volume at The Dalles Dam.

### 3.10.4 Tribal Interests

Effects to navigation and transportation resources may affect tribes in the region, depending on the MO.

The Inchelium-Gifford Ferry operations on Lake Roosevelt would be impacted under all MOs compared to the No Action Alternative. MO1, MO2, and MO3 would see a reduction of 9 days in wet years, increasing closure time by 33 percent and MO2 would see a reduction of 2 additional days. This would be an adverse effect to the Confederated Tribes of the Colville Reservation which relies on the ferry for transportation across the reservoir. Other than these effects, MO1, MO2, and MO4 would not have substantial changes to navigation or transportation costs in the study area. MO3, however, would have major effects to the current commercial navigation system on the Columbia River. Commercial navigation under MO3 would effectively be eliminated at the four LSR projects and all ports on the lower Snake River would be inaccessible. Shipping costs would also increase for individual shippers. Some tribes have commented that there are ongoing adverse 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, under all MOs. They note that these adverse effects, along with impairment of Indian treaty-reserved rights, may be reduced under MO3 (Nez Perce Tribe 2020).

# 3.11 RECREATION

## 3.11.1 Introduction and Background

The Columbia River Basin spans 258,000 square miles and includes a wide variety of ecosystems in a landscape of interspersed mountain ranges and valley floors. The operation of the CRS of dams and reservoirs regulates water flows, creating a mixture of reservoir and in-stream recreational opportunities. These opportunities are as varied as the ecosystems, attracting millions of recreational visitors each year. Additionally, the Pacific Ocean around the mouth of the Columbia River is highly valued as a recreation destination, offering opportunities unique to the coastal environment.

Recreational opportunities associated with fish and wildlife are among the most popular activities in this region. The Basin supports fish and wildlife habitat, including wildlife refuges and habitat management units that provide critical waterfowl nesting areas and feeding habitat for upland birds. Salmon, steelhead, sturgeon, walleye, bass, and rainbow trout are popular species for recreational fishing opportunities. Other water-based recreational activities include boating, rafting/paddling, and swimming. Land adjacent to rivers and reservoirs provides opportunities for hiking, hunting, birdwatching and wildlife viewing, photography, picnicking, and camping, among many other activities.

Fish of the Columbia River Basin are caught in commercial, recreational, and tribal ceremonial and subsistence fisheries both within the Basin and in the ocean off the coasts of Washington, Oregon, California, British Columbia, and Alaska. Fish are a natural resource of invaluable importance to the tribes of the region, and some tribes have reserved rights to catch fish, as specified in treaties signed with the United States. The Federal government has a trust responsibility to preserve the treaty-reserved rights of these tribes. The Fisheries and Passive Use section of this EIS (Section 3.15) discusses ceremonial and subsistence fishing activities, as well as commercial fishing activities, in more detail.

The Columbia River Basin offers a range of developed recreational opportunities. These include hiking trails, marinas, picnic areas, and campgrounds that offer amenities such as restrooms, showers, laundry facilities, water parks, and Wi-Fi. Overnight mooring is also available in some locations. Developed recreation sites are often near capacity on the weekends, especially during the summer months. Holiday weekends such as Memorial Day and Labor Day are especially popular for recreation.

Public access is a key component of outdoor recreation, and the Columbia River Basin comprises large blocks of public lands that are not readily available in other parts of the country. Public access laws in the Columbia River Basin vary based on the local, state, tribal, and Federal land management agency. Landforms, as well as other ecological factors and landowner preferences, are determining factors in the availability of public access.

Recreation sites include National Recreation Areas, National Wildlife Refuges, National Forests, state parks, county and municipal parks, port-operated marinas and boat launches, private lands, and others. Federal site managers include the Corps, Reclamation, the National Park Service (NPS), the U.S. Bureau of Land Management (BLM), USFWS, and the U.S. Forest Service (USFS). State-managed facilities in Washington, Oregon, Idaho, and western Montana located on both state lands and Reclamation-administered properties are operated by Washington State Parks and Recreation Commission (WSPRC) and WDFW; Oregon Parks and Recreation Department (OPRD) and ODFW; Idaho Department of Parks and Recreation (IDPR) and IDFG; and MFWP, respectively. At Lake Roosevelt, the Spokane Tribe of Indians and the Confederated Tribes of the Colville Reservation manage recreation in the parts of Lake Roosevelt National Recreation Area that fall within their respective reservation boundaries. This tribal management of recreation is one of the outcomes of the Lake Roosevelt Cooperative Management Agreement of 1990.

The level of recreation use, particularly for water-based recreation, depends on specific factors and site characteristics. These include the flows and elevations of rivers and reservoirs (water-based access); the number and quality of facilities at a site (e.g., campgrounds, restrooms, or marinas); proximity to population centers, which affects the travel cost and time to reach a site; water quality (e.g., clarity and cleanliness); availability of fish (i.e., abundance and types of species), which influences catch rates for anglers; crowding; the range of activities that can be pursued; and the amenities and aesthetic quality of the site/area.

Water levels fluctuate throughout the year, and between years, depending on the level of snow and rainfall in the region. In a regulated system, generally, reservoir levels are lowered in the winter in preparation for collection of spring snowmelt, and are filled again by the end of the spring freshet. In low precipitation years, the spring refill may not be as successful, leaving reservoir levels low throughout the summer. Low reservoir levels and river flows can negatively impact the accessibility of recreational boat ramps and rafting opportunities.

Recreational activities are valued by recreationists. The economic value of recreation is the difference between the maximum amount a recreationist would be willing to pay to participate in a recreational activity and the actual cost of participating in that activity. This is referred to by economists as *consumer surplus* or *net economic value*. Put simply, this is a recreationist's value of a trip after all expenses have been paid. For example, if a recreationist is willing to pay $105 to go rafting on the lower Snake River, but only incurs $75 of expenses, they receive $30 of consumer surplus value from their trip.

Recreational use of the Columbia River Basin also produces economic activity. As visitors travel to and from recreation areas, they spend money in local communities on food, gas, lodging, and other trip-related expenses. Visitors who live outside the Columbia River Basin stimulate economic activity and inject new money into local economies, supporting jobs and income for residents. For example, if a non-local recreationist spends $75 on gas, food, and other supplies to go rafting on the lower Snake River, these expenditures provide sales for businesses in the region. In turn, these businesses make purchases from other firms in the region to support their operations, and employees of these firms make additional purchases with their wages. The summation of these effects represents the total economic impact of recreational activities to the region, which can be measured in terms of sales (spending), jobs, income, and value added, although other measures may be used. Regional economic impacts are estimated by tracing expenditures for recreation through the regional economy (e.g., using an input-output model such as IMPLAN).

In addition to the economic benefits described above, recreation can positively impact the physical, mental, and social health of individuals and their communities (California State Parks 2005). These types of effects are described and evaluated for recreation under the other social effects analysis. Recreation benefits physical health by keeping people active and reducing obesity and the risk of chronic disease. It benefits mental health by relieving stress, reducing depression, and improving quality of life. With respect to strengthening communities, recreation supports family interactions and can build cultural and socioeconomic diversity, as public recreation areas are generally free to access or have low fees (California State Parks 2005).

The presence of dams and system operations have had long-term adverse effects on the recreational opportunities for area tribes, particularly for fishing and hunting. Section 3.16, *Cultural Resources*, and Section 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal Interests*, provide additional information about ongoing effects as well as unique effects of MOs on tribal subsistence activities and cultural practices.

The general study area for this section is further defined into regions using the Columbia River watersheds in which the CRS projects are located, which are identified as Regions A to D (Figure 3-221). Within the general area, the recreation analysis focuses on recreational lands and activities located within 1 mile of the mainstem rivers, since these lands and activities are likely to be affected directly by MOs. The analysis also addresses impacts associated with potential changes to visitation to other areas that may result from MOs. The county-based study area for the regional economic effects evaluation is described in Section 3.11.3.1.

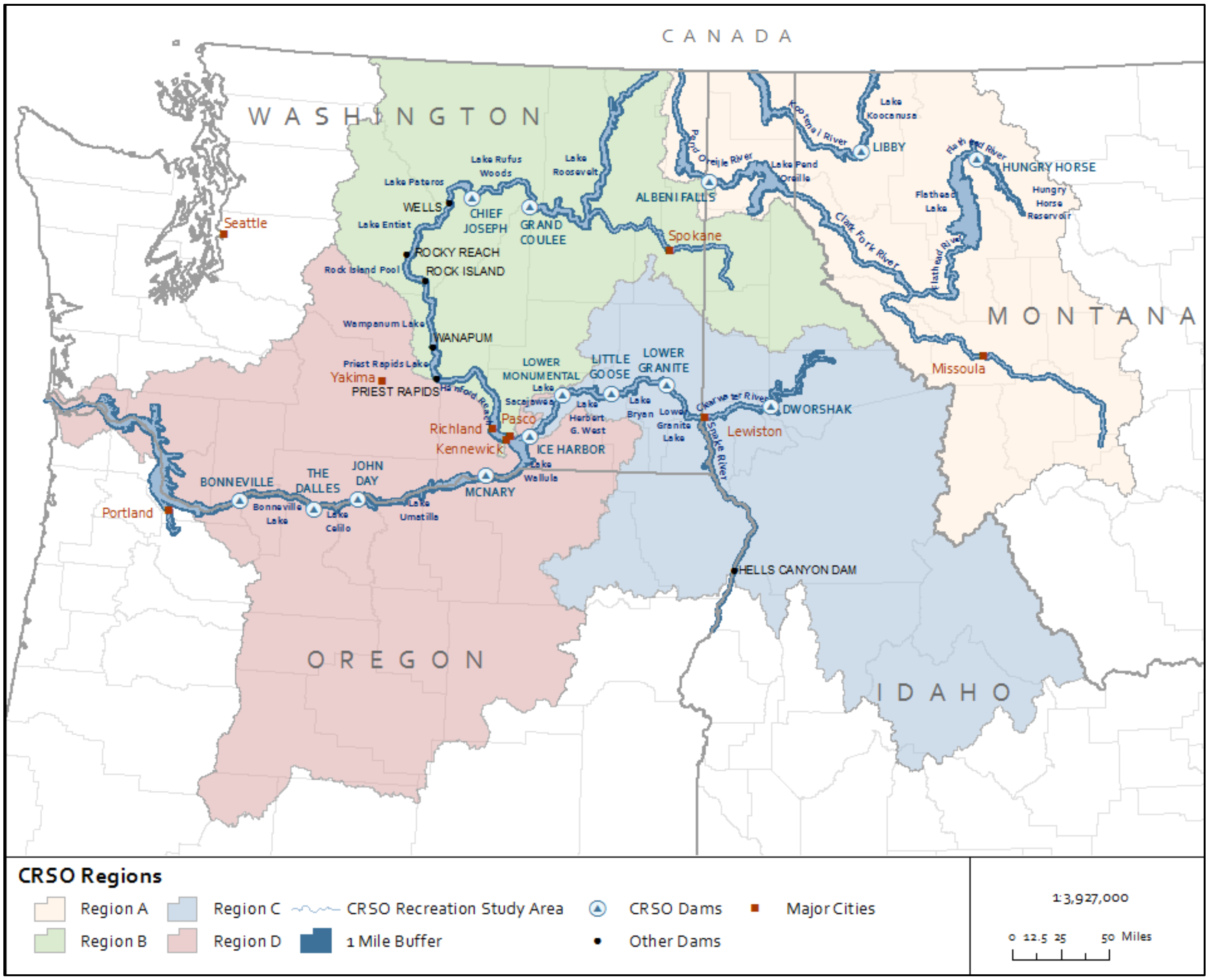



**Figure 3-221. Areas of Analysis for Recreation**

## 3.11.2 Affected Environment

This section describes the existing condition of recreational resources that may be affected by the alternatives under consideration:

- Section 3.11.2.1, *Recreation Areas*, summarizes recreation areas in the Columbia River Basin and adjacent Pacific Ocean. The discussion is organized by region. A brief summary of site characteristics and facilities is provided for major sites, along with a description of the recreational activities pursued.

- Section 3.11.2.2, *Recreational Visitation*, provides recreational visitation statistics from recent years for the sites described in Section 3.11.2.1. The environmental consequences section (and Appendix M, *Recreation*) assesses potential changes in visitation that may occur due to MOs and associated changes in economic benefits.

### *3.11.2.1 Recreation Areas*

This section provides a description of recreation areas in the Columbia River Basin. The study area is organized by CRS region and then by river reach within each region. A brief summary of characteristics and facilities is provided for major recreation areas, along with a description of the recreational opportunities available.

The summary of recreation areas focuses on sites managed by Federal and state agencies, primarily at reservoir recreation areas. Much of the recreation in the region occurs at these sites and visitation data is readily available from these agencies. Further, the summary focuses on recreation sites at reservoirs or on or near rivers in the Columbia River Basin. There are at least 550 on- or near-water recreation access points managed by Federal and state agencies within 1 mile of the mainstem rivers in the Columbia River Basin, which include boat launches, campgrounds, interpretive centers, and parks.

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

Region A spans parts of eastern Washington, northern Idaho, and northwestern Montana. It includes three Federal projects: Albeni Falls Dam, Libby Dam, and Hungry Horse Dam. Although the Columbia River does not flow through this region, it includes many Columbia River tributaries, including the Pend Oreille, Clark Fork, Flathead, and Kootenai Rivers. The region consists of the following reaches which include both CRS projects and other regionally important projects:

- Kootenai River between the U.S.-Canada border and Libby Dam/Lake Koocanusa
- South Fork Flathead River above Flathead Lake and Hungry Horse Dam and Reservoir
- Clark Fork River, Flathead River below Flathead Lake, and Flathead Lake
- Pend Oreille River and Lake Pend Oreille

The region contains at least 124 recreation access points on or near the mainstem rivers and reservoirs that are managed by Federal and state agencies. Table 3-252 summarizes land ownership for protected lands located within 1 mile of the mainstem rivers in Region A, many of which are accessible to recreationists. The USFS manages the largest acreage within 1 mile of the major tributaries of the Columbia River, managing approximately 50 percent of this area. The area includes portions of the Colville National Forest, Idaho Panhandle National Forests, Kootenai National Forest, Lolo National Forest, Flathead National Forest, and Beaverhead-Deerlodge National Forest. This region also includes lands of four Indian tribes: Kootenai Tribe , CSKT (Flathead Reservation), Kalispel Tribe, and Coeur D'Alene Tribe.

**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** |
| *BLM* | *9,966* | *1* |
| *DOD* | *22* | *0* |
| *NPS* | *1,943* | *0* |
| *NRCS* | *4,539* | *1* |
| *Reclamation* | *22,929* | *3* |
| *USFS* | *426,120* | *53* |
| *USFWS* | *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** |

Note: DOD = U.S. Department of Defense; NGO = non-governmental organization.
Source: USGS Gap Analysis Program (GAP), May 2016 Protected Areas Database of the United States (PAD-US), Version 1.4 Combined Feature Class

Travel to recreation access points along these rivers is supported by a network of mostly rural highways. Local recreational visitors come from Coeur d'Alene, Idaho; Kalispell and Missoula, Montana; and the surrounding areas. Lake Pend Oreille, Flathead Lake, Lake Koocanusa, and the river stretches in between, provide opportunities for fishing, boating, paddling, swimming, windsurfing, hunting, hiking, wildlife viewing, picnicking, and camping.

**Kootenai River Between the U.S.-Canada Border and Libby Dam/Lake Koocanusa**

The Kootenai River is one of the largest tributaries of the Columbia River. Libby Dam, located in Montana, was constructed near the confluence of the Kootenai and Columbia Rivers. Although the lake is relatively undeveloped, recreational activities such as boating, camping, fishing, hiking, and picnicking are popular. The Corps operates Libby Dam and its visitor center, a campground, and a boat ramp on Lake Koocanusa while USFS operates and manages all other recreational facilities along the reservoir. For Lake Koocanusa, recreation impacts in Canada are anticipated to be similar to those in the United States for all MOs.

**Flathead River Above Flathead Lake and Hungry Horse Dam and Reservoir**

Above Flathead Lake, the south fork of the Flathead River is impounded by Hungry Horse Dam. The Hungry Horse Visitor's Center and Dam, which forms the Hungry Horse Reservoir, are operated by Reclamation; however, administration of the recreation opportunities on the reservoir and the surrounding lands have been jurisdictionally transferred to USFS. The reservoir is approximately 34 miles long with 170 miles of shoreline. Located about 15 miles south of Glacier National Park, the reservoir is narrow and wedged between mountains of the Northern Rockies. The lake and adjacent area provide access for recreational fishing, boating, swimming, hiking, camping, and other activities. The area offers both primitive and developed recreational opportunities.

**Clark Fork River, Flathead River Below Flathead Lake, and Flathead Lake**

Flathead Lake in northwestern Montana spans 200 square miles and has 185 miles of shoreline. The lake is bordered by communities including Polson and Bigfork, Montana, and the Flathead Indian Reservation on the southern half of the lake. The portion of the lake overlapping the Flathead Indian Reservation is managed by the CSKT, while other sections of the lake are managed by MFWP. Recreational activities on the lake include fishing, boating, camping, swimming, hiking, biking, skiing, snowmobiling, and horseback riding. Note that Flathead Lake is not technically a Federal reservoir, however water surface elevations at this popular recreation destination are affected by releases from Hungry Horse Dam.

**Pend Oreille River and Lake Pend Oreille**

Lake Pend Oreille, a natural lake enlarged when the Corps constructed Albeni Falls Dam, is sourced from the lower Clark Fork and Pack Rivers and is the largest and deepest lake in Idaho. The 43-mile-long lake has a maximum depth of 1,200 feet and 111 miles of shoreline. Lake Pend Oreille is surrounded by a mountainous landscape. Dozens of developed recreation sites on the lake host recreational activities such as fishing, boating, sailing, paddling, camping, swimming, and waterskiing in the summer and cross-country skiing and snowmobiling in the winter. Other recreational activities along the lake include sightseeing, wildlife viewing, picnicking, scuba diving, hunting, hiking, and horseback riding. Campgrounds are managed by the Corps, USFS, IDFG, IDPR, and various cities, counties, and private concessionaires. Boat accessibility on Lake Pend Oreille and the Pend Oreille River is largely achieved via private docks (more than 2,000) and commercial and public marinas. Accessibility and usability of fixed docks and swimming areas, fishing conditions, and lake aesthetics are sensitive to changes in lake elevations.

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

Region B includes the Columbia River between the Tri-Cities (Richland, Kennewick, and Pasco) in Washington and the U.S.-Canada border. There are two CRS projects in this region, the Grand Coulee and Chief Joseph Dams, and several smaller dams managed by other entities. A prominent feature in this region is the Lake Roosevelt National Recreation Area. Created in 1941 with the construction of Grand Coulee Dam, it attracts the most recreational visitation in Region B. The river is accessible using rural highways throughout this region. The Hanford Reach, located below Priest Rapids Dam, is also a unique feature in this region because it is the only free-flowing reach on the Columbia River below Lake Roosevelt and is bordered almost entirely by wildlife refuges and open space. While public access is limited in the Hanford Nuclear Reservation, habitat for fish and wildlife provide abundant fishing, hunting, and wildlife viewing opportunities. The region consists of several CRS projects as well as some non-CRS projects and their associated lakes and reaches:

- Grand Coulee Dam and Lake Roosevelt
- Chief Joseph Dam and Rufus Woods Lake
- Wells Dam and Lake Pateros
- Rocky Reach Dam and Lake Entiat
- Rock Island Dam and reservoir
- Wanapum Dam and Wanapum Lake
- Priest Rapids Dam and Priest Rapids Lake
- The Hanford Reach below Priest Rapids Dam

The region encompasses at least 89 recreation access points on or near water that are managed by Federal and state agencies. Table 3-253 summarizes land ownership for protected lands located within 1 mile of the Columbia River in Region B, many of which are accessible to recreationists. Much of the area in Region B is managed by tribes, including lands of the Spokane Tribe of Indians and the Confederated Tribes of the Colville Reservation. The NPS manages approximately one-quarter of protected areas within 1 mile of the mainstem Columbia River, primarily associated with Lake Roosevelt National Recreation Area. The Hanford Reach National Historic Monument is also in this region.

**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 |
| *BLM* | *25,122* | *6* |
| *DOD* | *15,969* | *4* |
| *DOE* | *54,564* | *14* |
| *NRCS* | *903* | *0* |
| *Reclamation* | *218* | *0* |
| *USFS* | *4,750* | *1* |
| *USFWS* | *32,676* | *8* |
| 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** |

Source: USGS GAP, May 2016, PAD-US, Version 1.4 Combined Feature Class

Region B is relatively rural and most recreation sites are located at the Federal projects. Spokane, Washington is the most populated community in this region. Large tributaries in this region include the Yakima, Wenatchee, Entiat, Methow, Okanogan, and Spokane Rivers. A range of recreational activities are pursued in this region.

**Grand Coulee Dam and Lake Roosevelt**

Lake Roosevelt spans over 150 miles from Grand Coulee Dam to the U.S.-Canada border and features 600 miles of shoreline. The Colville National Forest, Colville Indian Reservation, Spokane Indian Reservation, and historic Fort Spokane are adjacent to the lake. Grand Coulee Dam is operated by Reclamation. Recreational access is managed by NPS, Confederated Tribes of the Colville Reservation, and the Spokane Tribe of Indians. Lake Roosevelt National Recreation Area, the portion of the lake managed by NPS, receives much of the annual visitation; mostly for camping, fishing, swimming, boating, and picnicking. Common sport fish caught in Lake Roosevelt include rainbow trout, kokanee, northern pike, burbot, white sturgeon, walleye, and perch. Access to the lake for recreation is restricted during drawdowns, and the minimum usable water elevations vary across boat ramps at the reservoir. The landscape surrounding Lake Roosevelt is relatively undeveloped except for a few farms and small communities. Visitors enjoy views of valleys and mountains beyond the lake, as well as rolling hills and undeveloped shoreline covered in rich coniferous forest. The Grand Coulee laser light show and dam tours are also popular visitor attractions.

**Chief Joseph Dam and Rufus Woods Lake**

Chief Joseph Dam, a Corps facility located about 2 miles upriver from Bridgeport, Washington, forms Rufus Woods Lake. The lake spans 51 miles up to Grand Coulee Dam. The surrounding landscape is rugged, featuring a canyon and granite cliffs, providing visitors with opportunities to hike, hunt, and view wildlife. Other recreational activities include boating, fishing (particularly for sturgeon and burbot), swimming, and camping. The Confederated Tribes of the Colville Reservation operate a net pen program, which contributes 50,000 to 70,000 triploid trout to the region's fishery annually.

**Priest Rapids Dam and Priest Rapids Lake to Wells Dam and Lake Pateros**

The reaches between Priest Rapids Dam (RM 397) and Chief Joseph Dam (RM 545) along the Columbia River are separated by four run-of-river dams: Wanapum Dam, Rock Island Dam, Rocky Reach Dam, and Wells Dam. Rock Island and Rocky Reach Dams are highly developed, featuring visitor centers, fish viewing rooms, restrooms, picnic shelters, and more. Scenic driving, featuring views of Cascade Range, cliffs along the river canyon, and fruit orchards, is the most popular recreational activity in the region (DOE, Corps, and Reclamation 1995). Water-related recreation such as fishing, boating, and swimming also occurs in the area.

**Hanford Reach Below Priest Rapids Dam**

The Hanford Reach between Priest Rapids Dam and Lake Wallula is the only free-flowing reach below Lake Roosevelt, and is located north of the Tri-Cities area upstream of McNary Dam. The landscape consists of shrub steppe communities, including sand dunes and native plant communities with views of nearby mountains. Much of the land is undeveloped, aside from the Hanford Site for which the reach is named. The cities of Pasco, Kennewick, and Richland, Washington; Benton County; WDFW; USFWS; and the Corps manage recreational opportunities within the reach. Vernita Bridge Water Access Site, operated by the USFWS, is a highly used primitive boat access point within the reach. Other unpaved boat ramps within the reach provide additional access for fishing, wildlife viewing, boating, and hunting. Fishing is the main attraction along this reach with anadromous fish, sturgeon, and walleye commonly targeted.

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

Region C includes the Snake River from its mouth at the Columbia River to Hells Canyon, as well as the Clearwater River from its mouth on the Snake River at Lewiston, Idaho, to Dworshak Dam. The four lower Snake River projects are located below Lewiston, Idaho, which is the most populated community in this region. Rural highways run adjacent to or near the water in Region C. Within the Wallowa-Whitman National Forest south of Lewiston, Idaho, the Snake River is designated a Wild and Scenic River up to Hells Canyon Dam. River reaches within Reach C that are potentially affected by changes in CRS operation include the following:

- Clearwater River (including North Fork) and Dworshak Dam/Reservoir
- Snake River below Hells Canyon Dam
- Lower Granite Dam and Lower Granite Lake
- Little Goose Dam and Lake Bryan
- Lower Monumental Dam and Lake Herbert G. West
- Ice Harbor Dam and Lake Sacajawea

Region C encompasses at least 129 recreation access points on or near water that are managed by Federal and state agencies and private (for profit) entities. Table 3-254 summarizes land ownership for protected lands located within 1 mile of the Snake and Clearwater Rivers in Region C, many of which are accessible to recreationists. The USFS manages more than half (58 percent) of protected lands in this area, and includes portions of a number of national forests. In addition to Wallowa-Whitman National Forest, the area includes portions of Hells Canyon Recreation Area and Wilderness Area, the Nez-Perce Clearwater National Forest, and Payette National Forest, among others. The Corps manages the lakes behind all of the Snake River dams in this region. Over 73,000 acres of Nez Perce Tribe lands are also located in the areas within 1 mile of the Snake River.

Population density throughout much of Region C is low and the riverbanks are often steep and rugged. Recreation sites vary from developed state and Federal lands to boat launches with limited amenities. Large tributaries of the Snake River in this region include the Palouse, Clearwater, Grande Ronde, and Salmon Rivers. A range of recreational activities are pursued in this region. Rafting is a particularly important use in this region relative to others, especially in Hells Canyon National Recreation Area (HCNRA).

**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 |
| *BLM* | *11,836* | *5* |
| *USFS* | *92,208* | *38* |
| *USFWS* | *153* | *0* |
| Tribal | 73,014 | 30 |
| State | 63,669 | 26 |
| Private/NGO | 7 | 0 |
| Other | 152 | 0 |
| Total Protected Lands | 241,037 | 100 |

Source: USGS GAP, May 2016, PAD-US, Version 1.4 Combined Feature Class

**Clearwater River and Dworshak Dam/Reservoir**

The Clearwater River empties into the lower Snake River at Lewiston, Idaho. The Dworshak Dam, operated by the Corps, is located at RM 1.9 on the north fork of the Clearwater River on the Nez Perce Reservation, and about 50 miles east of Lewiston, Idaho. The landscape surrounding the 717-foot dam is forested and mountainous, attracting campers, hunters, and fishers. The reservoir behind the dam provides excellent boating and waterskiing, with fixed swim docks and houseboat buoys. Two mitigation hatcheries, Dworshak Hatchery and Clearwater Hatchery, are located downstream of the dam on the north fork of the Clearwater River. These hatcheries produce steelhead, spring Chinook salmon, summer Chinook salmon, and coho salmon to support regional fisheries. The Dworshak Reservoir also offers unique, boat access campsites along the length of the reservoir, though most boat ramps are concentrated on the downstream end of the reservoir.

**Lower Granite Dam and Lower Granite Lake**

Lower Granite Dam is a Corps facility in southeastern Washington near the Idaho border. Lower Granite Lake extends 39 miles behind the dam to Lewiston, Idaho. The recreation areas along the lake are managed by the Corps and offer an array of outdoor activities, including walking trails, fishing, boating, hunting, and more. Lower Granite Dam also provides wildlife observation, including fish viewing rooms. Many recreation sites provide picnic areas, campsites, and boat ramps.

### Little Goose Dam and Lake Bryan

Little Goose Lock and Dam, a Corps facility 70 miles upriver from the mouth of the Snake River, forms Lake Bryan. The landscape includes open vistas, steep canyon walls, sand dunes, and few trees. Developed sites along Lake Bryan include two that are leased from the Corps by the State of Washington and one that is leased by the Port of Whitman County. Recreation development at Lake West is also limited, largely due to the high cliffs that surround the reservoir. Recreation sites are primarily managed and operated by the Corps, though some are operated by other entities. Popular activities in the area include camping, hunting, boating, swimming, waterskiing, fishing, and wildlife viewing. Facilities along Little Goose Dam and Lake Bryan include campgrounds, boat ramps, and swimming areas.

### Lower Monumental Dam and Lake Herbert G. West

Lower Monumental Dam and Lake West, a Corps facility, is situated near the confluence of the Snake and Palouse Rivers in southeastern Washington. The lake extends 28 miles east to Little Goose Dam. Visitors walk, hunt, picnic, view wildlife, and camp in the area. Lake West offers water activities such as fishing and boating.

### Ice Harbor Dam and Lake Sacajawea

Ice Harbor Dam and Lake Sacajawea is a Corps facility on the lower Snake River, about 45 miles northwest of Walla Walla, Washington. The open landscape provides the public with opportunities to walk, hunt, and camp. The lake itself is popular for boating, fishing, swimming, and waterskiing. Wildlife observation opportunities include birdwatching at the adjacent wildlife refuge or habitat management units. The visitor center at the dam provides opportunity to see salmon migrate upstream.

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

Region D includes the Columbia River from the mouth at the Pacific Ocean to the Tri-Cities area in Washington. A prominent feature in this region is the Columbia River Gorge National Scenic Area, which is managed by the USFS. As the largest national scenic area in the United States, it is 80 miles long and the surrounding basalt canyon is up to 4,000 feet deep in some locations. Highway 84 runs along the river in the gorge and provides the only sea level route through the Cascade Range. The gorge is among the most popular areas within the Columbia River Basin, and draws visitors from throughout the United States. In the western portion of the gorge (west of Hood River, Oregon), the Columbia River gradually widens and the landscape is characterized by rolling hills and low-lying valleys. The most populated communities in this region include the areas around Portland, Oregon, and Vancouver, Washington. The river in this region has several reaches, which consist of the four lower Columbia River projects:

- McNary Dam and Lake Wallula
- John Day Dam and Lake Umatilla

- The Dalles Dam and Lake Celilo
- Bonneville Dam and Lake Bonneville
- Downstream of Bonneville Dam

Large tributaries of the Columbia River in this region include the Cowlitz, Lewis, Willamette, White Salmon, Hood, Deschutes, John Day, Umatilla, and Walla Walla Rivers. The reaches along the Columbia River in this region include a series of dams and reservoirs with numerous developed recreation sites. A substantial portion of water-based recreation in the Columbia River Basin takes place in the reservoirs created by the Bonneville, The Dalles, John Day, and McNary Dams (DOE, Corps, and Reclamation 1995). Dozens of access points are found along these reservoirs.

The region encompasses at least 215 access points on or near water that are managed by Federal and State agencies. Table 3-255 summarizes land ownership for protected lands located within 1 mile of the Columbia River in Region D, many of which are accessible to recreationists. The USFS manages the largest share of protected lands in this region, with USFWS and the Corps also managing a substantial share of lands. In addition to the Columbia River Gorge National Scenic Area, a portion of the Lewis and Clark National Historic Trail is in this region.

**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 |
| *BLM* | *8,580* | *5* |
| *DOD* | *70* | *0* |
| *DOE* | *603* | *0* |
| *NPS* | *164* | *0* |
| *NRCS* | *526* | *0* |
| *USFS* | *40,047* | *22* |
| *USFWS* | *69,721* | *38* |
| 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** |

Source: USGS GAP, May 2016, PAD-US, Version 1.4 Combined Feature Class

**McNary Dam and Lake Wallula**

McNary Dam and Lake Wallula are operated and managed by the Corps. The dam sits on the Columbia River at RM 292 near the Tri-Cities area and the lake extends to about RM 335. Public recreation on the lake include water sports, boating, wildlife viewing, fishing and picnicking. Lake Wallula, its 242 miles of shoreline, and its surrounding landscape is a mixture of parks, agriculture, and private developed land. The USFWS operates the McNary National Wildlife Refuge near the confluence of the Columbia River with the Snake River. A number of developed marinas and boat launches provide boating access near the Tri-Cities area.

**John Day Dam and Lake Umatilla**

The John Day Dam, roughly equidistant from Portland, Oregon, and the Tri-Cities area in Washington, is a Corps facility at RM 216 that forms the 76-mile-long Lake Umatilla. Umatilla National Wildlife Refuge is located on Lake Umatilla, and provides opportunities for hunting, fishing, and wildlife viewing. Campgrounds along the lake operated by the Corps are open seasonally. Recreation areas along the lake support boating, swimming, camping, fishing, hunting, walking, windsurfing, and other activities.

**The Dalles Dam and Lake Celilo**

The Dalles Dam, operated by the Corps, is located at RM 192 and forms Lake Celilo. The lake is approximately 24 miles long. The recreation areas around The Dalles Dam and Lake Celilo offer views of several notable mountain peaks, including Mount Hood. Amenities include walking trails, picnic areas, campgrounds, and boat ramps. The dam and grounds are operated and managed by the Corps.

**Bonneville Dam and Lake Bonneville**

Bonneville Lock and Dam, a National Historic Landmark operated by the Corps, is located within the Columbia River Gorge National Scenic Area at RM 146. Lake Bonneville extends 46 miles east to The Dalles Dam. The area is also maintained and operated for recreation by the Corps. The three visitor’s centers at Bonneville Dam offer tours of the powerhouse, hatchery, and the sturgeon center, and provide interpretive information about regional history and cultures. Lake Bonneville and the surrounding area are used for picnicking, sightseeing, wildlife viewing, fishing, boating, waterskiing, windsurfing, and other activities. Recreation sites along the lakeshore offer amenities including campgrounds, swimming beaches, and recreational trails.

**Downstream of Bonneville Dam**

The Columbia River is free flowing below Bonneville Dam and is tidally influenced. Given these characteristics, along with close proximity to the Pacific Ocean and major population centers, including Portland, Oregon, recreational fishing and boating are popular uses of the river. Other important activities include paddling, swimming, windsurfing, hunting, hiking, wildlife viewing, and camping. There are numerous city, county, state, and Federal lands in this region that have been developed for recreation use. A number of small businesses are dependent on the recreational draw of the area including restaurants, wineries, and specialty shops. The Willamette River, which empties into the Columbia just north of Portland, Oregon, is a large tributary in this reach.

The Pacific Ocean off the coasts of Oregon and Washington provides recreational opportunities for visiting the beach, crabbing, clamming, sunbathing, sightseeing, hiking, and fishing.

Columbia River Basin anadromous fish support recreational ocean fishing. Fishing for these species occurs primarily by private boat and charter vessels, though some recreational fishing effort occurs from sandy beaches, jetties, piers, and other features along the shoreline (NMFS 2014b; TRG 2015). NMFS manages recreational fishing in Federal waters (3 to 200 miles from shore) while the states manage ocean fishing in their coastal waters (0 to 3 miles from shore).

#### *3.11.2.2 Recreational Visitation*

This section presents recreational visitation estimates from recent years for the sites described in Section 3.11.2.1, *Recreation Areas*. This data was compiled with assistance from Federal and state agencies. These agencies estimate visitation using a range of methods, including direct counts by field staff, counts by automated traffic and trail counters, permit and fee information, and professional judgment. Visitor surveys are used to understand trip characteristics, such as group size, activities, and length of stay.

Due to gaps in existing information, visitation estimates are not available for all sites.[1] Additional details on available recreational visitation data for the Basin is provided in Appendix M Recreation.

Table 3-256 presents available annual visitation estimates for 2017 and 2018 and the distribution of monthly visitation for 2018. Consistent visitation data for years prior to 2017 is not available from all Federal and state agencies. Further, based on conversations with the H&H Team and recreation managers, 2017 and 2018 represent relatively typical years in terms of water levels and recreational visitation. Across the Basin, total recreational visitation at sites within 1 mile of the mainstem rivers, including water- and land-based use at reservoirs and river reaches, exceeds 13 million visits annually, with most visitation occurring in summer months.[2] The top three most-visited sites/reaches in recent years with available data are McNary Dam and Lake Wallula, Lower Granite Dam and Lower Granite Lake, and Bonneville Dam and Lake Bonneville.

Some of the most commonly pursued activities in the region include fishing, sightseeing, boating, swimming, picnicking, and camping. Table 3-257 summarizes the distribution of recreation use at reservoirs/river reaches where such data is available. The most recent information is presented, which is from 2016.

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[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.

**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 |

| 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** |

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 H&H modeling results (see Table 3-222 for locations where a change in boat ramp accessibility change may occur).

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 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 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 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 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 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.

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.

Visitation data for sites managed by Reclamation is collected by partner agencies.

Totals and percentages presented in this table combine fiscal and calendar year data across agencies. Data from BLM, Corps, and USFWS reflects fiscal years while all other agencies provide data by calendar year.

1/ Percentages are based on available monthly data from Federal and state agencies. Some agencies only report annual data.

Source: MFWP 2017–2018 and email communication; NPS 2019a; other visitation data provided through personal communication with BLM, Corps, USFWS, USFS, IDPR, OPRD, and WSPRC.

**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 Koocanusa | 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% |

| 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% |

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 upon H&H modeling results (see Table 3-222 for locations where a change in boat ramp accessibility change may occur).

Data on recreational activities is not collected at all sites, even for those with visitation data reported in Table 3-256.

Source: Corps 2016d; Le and Strawn 2017

### 3.11.3 Environmental Consequences

The environmental consequences analysis for recreation evaluates how changes in reservoir, river, and habitat conditions under MOs could affect visitation, recreational opportunities, and the value of the recreation experience. This section provides an overview of the recreation impact assessment methodology and presents the results of the assessment. A more detailed description of the methodology, data, and results is provided in the Appendix M Recreation.

#### *3.11.3.1 Methodology*

The environmental consequences for recreation are evaluated across three categories: social welfare effects (i.e., national economic development, or NED), regional economic effects (i.e., regional economic development, or RED), and other social effects. These categories provide an organizing framework for evaluating direct and indirect effects, and for displaying potential effects important to stakeholders and tribes, while ensuring effects are not double-counted. The following sections provide a brief overview of the methodology used to evaluate the effects by category.

River flows and reservoir elevations may change under the MOs as compared to the No Action Alternative, which may cause changes in access to water-based recreation and may affect the quality of recreational experiences. Decreased access to water-based recreation—which includes fishing, boating, and swimming—would affect the amount of visitation to a site and associated benefits to visitors and communities. Under MO3 water-based recreation on the lower Snake River would change from reservoir recreation to riverine recreation, with different water-based recreation conditions in the short term during dam breaching implementation, versus the longer term.

The recreation analysis uses outputs from the H&H analysis, which simulates reservoir operations and river conditions under each MO within a Monte Carlo framework (the H&H modeling methods are described in Section 3.2). Reservoir elevation data from the H&H analysis is compared to usable boat ramp elevations. Water surface elevations are compared with minimum usable boat ramp elevations to assess the accessibility for water-based recreators and estimate effects on recreational visitor days at reservoirs.[3] A supplemental analysis applying existing information is used to quantify potential changes in recreational visitor day under for the dam breach scenario under the MOs.

While effects to water-based visitation from changes in boat ramp accessibility and/or lower Snake River Dam breach are quantified, effects to river activities and non-water reservoir activities are assessed qualitatively (e.g., changes in aesthetics/recreation setting due to changes in flow and water surface elevations). Changes in river flows and stages during the peak recreation season (May through September), where changes in flow of 10 percent or 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.

in flows that would be outside of the peak recreation season are assumed to result in negligible effects to recreation.

Potential effects to recreation-related resources and conditions, including recreational fishing, water quality, and wildlife and habitat conditions, provide information about changes to the quality of the recreation experience that may result from the MOs.

**SOCIAL WELFARE EFFECTS**

Social welfare effects consider both the change in the number of visitors (recreational visitor days) that could occur, as well as the change in type of recreational activities and conditions that could affect the quality of recreation experience. The analysis includes an assessment of effects on a range of activities, including recreational fishing for anadromous and resident fish species, boating, rafting/paddling opportunities, swimming, hunting, and wildlife viewing. Effects to all recreationists (tribal and non-tribal) are considered in this analysis. Section 3.16, Cultural Resources, and Section 3.17, Indian Trust Assets, Tribal Perspectives, and Tribal Interests, provide additional information about ongoing effects as well unique effects of the alternatives on tribal recreational activities, subsistence activities, and cultural practices.

The analysis considers the effects of the MOs on recreation over the 50-year period of analysis. The 50-year period of analysis provide a long-term perspective, and enables the analysis to distinguish between short-term and long-term impacts, recognizing that the effects to recreation would likely be different, especially under MO3 in the short versus long term. The evaluation considered the effects of hydrologic changes on annual visitation in the typical water level year, as well as years with higher and lower water surface elevations. Although many factors can contribute to visitation (price of gas, population growth, climate change, and others), many of which are difficult to predict, the quantitative evaluation was focused on how changes in boat ramp accessibility could affect water-based visitation, as well as how dam breach of the lower Snake River projects (under MO3 only), could affect visitation. The results are presented for the No Action and MOs as annual or annual equivalent effects over the 50-year period of analysis.

**Recreational Visitation**

Decreased access to water-based recreation—which includes fishing, boating, and swimming—would affect the amount of visitation to a site and associated benefits to visitors and communities. The H&H analysis provides summary elevation and discharge hydrographs for reservoirs and river reaches for each alternative. The hydrographs provide the 1 percent, 25 percent, 50 percent, 75 percent, and 99 percent exceedance water levels on each day of the year. Results are also provided at the monthly level. The 50th percentile exceedance water level is referred to as the “median water surface elevation” or the “water level in a typical year” throughout this section. The recreation analysis uses the H&H hydrographs, in conjunction with minimum usable boat ramp elevations, to assess changes in accessibility of boat ramps under the MOs relative to the No Action Alternative. Visitation data for the reservoir sites is readily available from Federal and state agencies, while visitation data for river reaches is limited.

Therefore, changes in boat ramp accessibility—and associated water-based recreational visitation, such as boating and fishing—are estimated quantitatively at reservoirs only and are described qualitatively for river reaches. The methodology for estimating changes in water-based visitation at reservoirs is outlined below.

- **Estimate boat ramp accessibility under the No Action Alternative by reservoir**. Compare minimum elevations required for boat ramps with modeled water surface elevations to evaluate boat ramp accessibility by day under the No Action Alternative. The analysis focuses on modeled daily water surface elevations associated with the 50th percentile (typical year). These calculations are repeated for an average high-water-level year (25th percentile) and an average low-water level-year (75th percentile) to understand variation in the results. For each reservoir, the number of "accessible days," or days with water surface elevations above the minimum usable boat ramp elevations, is summed across boat ramps by month.
- **Calculate the change in boat ramp accessibility under each MO**. Calculate the percentage change in boat ramp accessibility by month for each MO relative to the No Action Alternative based on the percentage change in total days that boat ramps would be accessible in each month. For example, assume there are two boat ramps on a reservoir that are accessible on every day within a month under the No Action Alternative. If one of the two boat ramps is projected to be inaccessible for half of the month under an MO, then the change in accessibility is assumed to be reduced by 25 percent for that reservoir for that month.[4]
- **Estimate water-based visitation by reservoir under the No Action Alternative**. Monthly water-based visitation in a typical year (i.e., $50^{th}$ percentile) under the No Action Alternative is estimated using reported reservoir visitation data from recent years and applying the estimated proportion of water-based activities at each reservoir (fishing, boating, and swimming).
- **Estimate changes in water-based visitation by reservoir associated with changes in boat ramp accessibility**. The estimated changes in monthly boat ramp accessibility (Step 2) are multiplied by the monthly estimates of water-based visitation (Step 3) to calculate monthly changes in water-based visitation at each reservoir. Combining results across months yields annual changes.

The methodology presented above includes a number of assumptions due to data limitations. In particular, specific data about the behavior of recreationists when faced with varying river and reservoir conditions in the Basin is not known with certainty. The assumptions used in this analysis are conservative, i.e., they are more likely to overstate than understate effects of 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.

potential for spatial substitution or temporal substitution.[5] Quantified effects do not take into account potential actions that might be taken by resource managers to make a ramp accessible under alternative water surface elevations (e.g., extending a ramp). The approach also uses boat ramp accessibility as a representation of water-based recreation activity on the reservoirs. That is, all water-based recreation is assumed to decrease when a boat ramp is inaccessible. While some water-based activities, like shore fishing and swimming, might not vary in the same manner as activities that rely directly on boat ramps (e.g., motorized boating), the assumption was supported by conversations with reservoir recreation managers (Bureau of Recreation Natural Resource Managers 2019).

Recreation visitation under MO3, particularly on the lower Snake River and at Lake Wallula, would be impacted differently than what is described above. Lake Wallula (the reservoir created by McNary Dam downstream of Ice Harbor Dam) would be affected by sediment moving down from the lower Snake River during breaching activities. As discussed in the River Mechanics Appendix (Appendix C), the effects of the 2 to 7 years of sedimentation would primarily affect water-based recreation and boat ramp accessibility along the east and south sides of the Columbia River in Lake Wallula below the mouth of the Snake River. This information was used to assess the potential reductions in water-based visitation at certain recreation areas and associated economic effects affected by sedimentation at Lake Wallula. The process and timing for sediment movement through the system is described in detail in the River Mechanics section (Section 3.3).

A supplemental analysis was conducted under MO3 for the four lower Snake River projects, which would be uniquely affected by dam breaching. Recreation at the four lower Snake River projects—Lower Granite Dam and Lake, Little Goose Dam/Lake Bryan, Lower Monumental Dam/Lake Herbert G. West, and Ice Harbor Dam/Lake Sacajawea—would transition from reservoir-based recreation to river-based recreation. Recognizing that land-based recreation may return sooner than water-based recreation, the supplemental analysis quantifies potential changes in water and land-based recreation at the four lower Snake River reservoirs under MO3.

After and possibly during the breaching and infrastructure drawdown period, land-based recreational activities at lower Snake River sites would likely reoccur as areas are reopened and access is provided to curious sightseers, picnickers, hikers and others doing land-based activities. Therefore, the recreation evaluation estimates both reductions in land- and water-based visitation during dam breach, as well as a return of land based visitation shortly after breaching as recreation areas become available. This information was used to assess the potential changes in short term visitation and associated economic effects in the lower Snake 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.

Potential increases in visitation associated with the new river recreational opportunities in the long-term (e.g., fishing, rafting, paddling, as well as land-based activities) are evaluated through a review of previous studies and similar river reaches. However, the issue of recreation access is also discussed under MO3. Without the federal reservoirs the Corps will not have a role in providing recreation facilities, therefore in order to reestablish recreation opportunities and water access in the region, there would likely be a cost impact to a government agency.

The potential for recreational fishing in the long term and the quality of the recreational experience under MO3 uses information provided in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, which describes the increases in the abundance of anadromous recreational fishing species due to dam breaching under MO3. The evaluation also describes the possible limitations associated with recreational fishing activities, including the elimination of federally funded hatchery production operations associated with the four lower Snake River projects and fishing regulations to protect the ESA-listed species. However, the value (consumer surplus) for recreational fishing may also increase due to increased abundance and diversity of wild fish, which is described qualitatively.

Across the MOs, a change in recreational visitation due to changes in boat ramp accessibility is anticipated at nine CRS reservoirs (Table 3-258). This is based on the H&H modeling results as well as information related to the lower Snake River dam breaches under MO3. Additional non-CRS reservoirs in the system were also assessed, but no changes in boat ramp accessibility would be anticipated because changes in water surface elevations would be negligible.

**Table 3-258. Columbia River System Operations Reservoirs Where a Change in Boat Ramp 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 | | | | | |

Note: The sites marked with an “X” were identified as exhibiting changes in site accessibility using H&H modeling results. The sites with an asterisk (*) were analyzed separately using information related to the lower Snake River dam breaches under MO3. “**” marks potential effects at Lake Pend Oreille in low water years only.

**Consumer Surplus Value of Recreational Visitation**

Social welfare effects are evaluated by estimating the change in economic value (i.e., consumer surplus) resulting from estimated changes in recreational visitation at reservoirs. The procedures described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Water Resources Council 1983) (Principals and Guidelines) outline three generally accepted methods for measuring recreational benefits: the unit day value (UDV), the travel cost method, and contingent valuation. Although a current site specific travel cost or contingent value approach would be a preferred method, a more detailed analysis at this geographic scale was not possible under the timeline of the study. Therefore the recreation analysis uses another standard Corps approach to evaluate recreation consumer surplus benefit, the UDV approach (Corps 2019; Water Resources Council 1983). The UDV method relies on expert and informed opinion to assign relative values to recreational visits based on the quality of recreational opportunities supported by individual recreation areas. The UDV approach provides a consistent approach across all sites in the evaluation (Chang 2019).[6]

The social welfare analysis is done in two steps. First, recreational visits are converted to recreational visitor days to account for the fact that overnight trips are longer than 1 day (refer to Recreation Appendix M, Section 2.2 for additional details on recreation visitor day calculation). Once all visits have been standardized to days, the UDV approach can be applied. The most recent UDVs (FY 2018) were used for this analysis and updated to 2019 dollars using the Consumer Price Index (CPI; Bureau of Labor Statistics 2019). The UDV estimates range from $7.95 to $9.87 per day, depending on the project. The UDV estimates were obtained from the Corps Recreation Budget Evaluation System (RecBest) (Chang 2019). Additional details on the calculation of UDV by reservoir are provided in Appendix M.

**Quality of Recreational Experience**

In addition to factors that may affect site visitation through changes to accessibility, other factors under the MOs may also affect the quality of recreational experiences. These include effects associated with changes in recreational fishing conditions, water quality conditions, and hunting and wildlife viewing conditions. While changes in the quality of recreational experiences may also influence visitation, the effects are more difficult to quantify given the data available for this analysis. For this reason, effects of changes to site conditions that would 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.

### *Fishing Conditions*

The analysis described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, provides information on anticipated changes in population characteristics for a range of fish species across different reaches (i.e., reservoirs and sections of river) for each MO. The information includes anadromous species—including several salmonids, Pacific lamprey, sturgeon, American shad, and eulachon—and resident species, including trout, smallmouth bass, walleye, burbot, channel catfish, and northern pikeminnow. Many of these species are targeted by recreational anglers throughout the Basin. Reservoirs provide substantial warm-water fishing opportunities for resident species, while anadromous species are often targeted in cold-water river fisheries.

The MOs that improve fish survival and abundance would generally result in beneficial effects for recreational fishing, while MOs that reduce fish survival and abundance would adversely affect recreational fishing.[7] In particular, the presence of additional fish may improve the quality of existing recreational fishing trips (e.g., through increased catch rates), resulting in additional value (consumer surplus) for anglers (i.e., a higher UDV). Additional fish may also generate additional trips as more anglers could be supported (Melstrom et al. 2015; Poe et al. 2013). Different types of recreational fishing opportunities (e.g., reservoir versus river) often necessitate specialized gear and equipment for targeting specific sport fish species as well as different fishing techniques (e.g., fly fishing, boat fishing, shore fishing). It is noted that a change in recreational fishing opportunities from reservoir to river fishing would have impacts on individuals seeking specific opportunities even if overall recreational use data percentages remain stable for fishing activities within a region. Non-fishing recreational activities would likely not be affected by changes in fish abundance or distribution, though changes in the levels of angler visitation could affect crowding at sites. The effects to fishing visitation and experience and associated recreation consumer surplus are evaluated qualitatively based on the results of the fish analysis.

### *Water Quality Conditions*

The water quality analysis (Section 3.4) summarizes the effects of the MOs on a range of water quality metrics in affected river reaches and reservoirs.[8] Water quality metrics that have the potential to affect the quality and quantity of recreational visits include the following:

- Water temperature, which has the potential to affect the attractiveness of particular sites for in-water activities such as swimming.
- Total suspended solids/turbidity and light attenuation, which affect water clarity. Changes in aesthetics from enhanced or diminished water clarity can affect a range of water- and land-based recreational activities.

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[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.

- Nutrient loading (nitrogen and phosphorous); organic compounds/metals in water, sediment, and fish tissue; chlorophyll a; and coliforms and other microbes, which affect the likelihood of algal blooms and are reflective of pollution levels. Changes in the occurrence or frequency of algal blooms as well as pollutant levels have the potential to affect the attractiveness of particular sites for recreation (e.g., adverse changes to aesthetics/setting) and lead to health and safety concerns (Graham, Dubrovsky, and Eberts 2017). Metals in fish tissue that lead to the issuance or strengthening of fish consumption advisories (FCAs) would have an adverse effect on recreational anglers in particular.

***Hunting and Wildlife Viewing Conditions***

The vegetation, wildlife, floodplains, and wetlands analyses (Section 3.6) provide information on anticipated changes in habitat conditions for wildlife, including ESA-listed mammals, birds, amphibians and plants. Changes in habitat conditions for species valued by hunters, wildlife viewers, and other outdoor recreationists have the potential to affect the quality of the recreation experience for these visitors and potentially the number of trips taken for these activities. As noted above, Section 3.16, *Cultural Resources*, and Section 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal Interests*, provide additional information about ongoing effects as well as the unique effects of the MOs on tribal recreational activities, subsistence activities, and cultural practices.

**REGIONAL ECONOMIC EFFECTS**

Regional economic effects are measures of changes in economic activity as a result of changes in expenditures (also known as visitor spending) associated with recreational visitation. The approach to assess the regional economic effects is briefly described in this section. First, quantified changes in visitation resulting from changes in water surface elevations and boat ramp accessibility (results from the social welfare effects evaluation) are multiplied by per-day visitor spending estimates for recreation in the region.

The change in non-local visitation was estimated based on data on visitation patterns at affected sites. The focus of the regional economic effects evaluation was on non-local visitors because, while local visitors are likely to continue to spend money in the affected area even if they forgo particular recreation trips, non-local visitors may divert spending to other areas if particular trips are not taken due to access issues. A majority of visitors in the study area are considered to be non-local (agencies define local by the distance travelled to sites, which is generally 30 or 60 miles, depending on agency). The percentage of visitors who are non-local are presented by reservoir/river reach, CRS region, and in total in Appendix M.

Second, estimates of non-local visitor spending are used to estimate the broader effects on regional economic activity in terms of jobs, income, and sales using the input-output model, IMPLAN. IMPLAN is a widely used industry-standard input-output data and software system that is used by many Federal and state agencies to estimate regional economic effects. The underlying data for IMPLAN is derived from multiple sources, including the Bureau of Economic

Analysis, the Bureau of Labor Statistics, and the U.S. Census Bureau. Any potential effects to regional economies associated with changes in recreation quality are discussed qualitatively.

Regional economic effects are presented by CRS region and in total for the Basin. The study area for each region includes multi-county areas. IMPLAN data for these multi-county areas was used for this analysis; Table 3-259 lists the counties in each CRS region. A county was assigned to a CRS region if the majority of the county's area lies within the region.

**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) |

## OTHER SOCIAL EFFECTS

Other social effects include additional effects associated with changes in recreation conditions and activities that are not already captured in the social welfare and regional economic effects analyses. Given this, other social effects may include changes that affect community well-being, identity, or cohesion. Social effects could occur if there is a substantial change in recreation opportunities or displacement of recreation that result in a change in the number of tourism and recreation businesses in a particular community, affecting community well-being, stability, community cohesion, or all of the above. These effects are evaluated qualitatively based on the results of the recreation social welfare and regional economic effects evaluations. As noted above, Section 3.16, *Cultural Resources*, and Section 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal Interests*, provide additional information about ongoing effects as well unique effects of MOs on tribal recreational activities and cultural practices.

### *3.11.3.2 No Action Alternative*

Visitation data for 2017 and 2018 is used to estimate annual visitation for the period of analysis under the No Action Alternative, which is assumed to represent a typical year of visitation. Using 2017–2018 visitation in future years under the No Action Alternative is supported by recent visitation trends at Lake Roosevelt and communications with recreation managers.[9] Visitation estimates are used to estimate recreational consumer surplus values and regional economic effects, which are presented in this section.

The No Action Alternative would continue to provide social welfare benefits, regional economic benefits, and other social benefits 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.

#### REGION A

As stated in the Affected Environment section, Region A contains at least 124 recreation access points on or near the mainstem rivers and reservoirs that are managed by Federal and state agencies. The area includes portions of the Colville National Forest, Idaho Panhandle National Forests, Kootenai National Forest, Lolo National Forest, Flathead National Forest, and Beaverhead-Deerlodge National Forest. This region also includes lands of four Indian Tribes: the Kootenai Tribe, CSKT (Flathead Reservation), Kalispel Tribe, and Coeur D'Alene Tribe. Average visitation to sites within a mile of the river in Region A was estimated to be 1.5 million in 2017–2018. This analysis assumes that visitation would continue under the No Action Alternative.

A wide range of land- and water-based recreation would occur under the No Action Alternative, with most visitation occurring at Lake Koocanusa, Hungry Horse Reservoir, and Albeni Falls/Lake Pend Oreille. Regional visitation would generate annual welfare benefits of $15 million. Visitor expenditures associated with non-local visitors of at least $67 million annually would support 860 annual jobs, $30 million in regional labor income, and $88 million in regional sales annually. For comparison, total economic activity in Region A supports 644,600 jobs, $30.2 billion in labor 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.

**REGION B**

Region B encompasses at least 89 recreation access points on or near water that are managed by Federal and State agencies. Table 3-253 summarizes land ownership for protected lands located within 1 mile of the Columbia River in Region B, many of which are accessible to recreationists. This area includes lands of the Spokane Tribe of Indians and the Confederated Tribes of the Colville Reservation. The NPS manages approximately one-quarter of protected areas within 1 mile of the mainstem Columbia River, primarily associated with Lake Roosevelt National Recreation Area. The Hanford Reach National Historic Monument is also in this region. Average visitation to sites within a mile of the river in Region B was estimated to be 2 million in 2017–2018. This analysis assumes that visitation would continue under the No Action Alternative.

A wide range of land- and water-based recreation would occur under the No Action Alternative, with most visitation occurring at Lake Roosevelt, and to a lesser extent at Rufus Woods Lake. Regional visitation would generate annual welfare benefits of $25 million. Visitor expenditures associated with non-local visitation of at least $77 million annually would support approximately 840 annual jobs, $26 million in regional labor income, and $88 million in regional sales annually. For comparison, total economic activity in Region B supports approximately 180,000 jobs, $8.6 billion in labor income, and $25.6 billion in sales annually (IMPLAN 2017).

**REGION C**

Region C encompasses at least 129 recreation access points on or near water that are managed by Federal and state agencies and private (for profit) entities. Table 3-254 summarizes land ownership for protected lands located within 1 mile of the Snake and Clearwater Rivers in Region C, many of which are accessible to recreationists. The USFS manages more than half (58 percent) of protected lands in this area, which includes portions of a number of national forests. In addition to Wallowa-Whitman National Forest, the area includes portions of Hells Canyon Recreation Area and Wilderness Area, the Nez-Perce Clearwater National Forest, and Payette National Forest, among others. The Corps manages the lakes behind all of the Snake River dams in this region. Over 73,000 acres of Nez Perce Tribe lands are also captured in the areas within 1 mile of the Snake River. Average visitation to sites within a mile of the river in Region C was estimated to be approximately 3 million in 2017–2018. This analysis assumes that visitation would continue under the No Action Alternative.

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, Idaho. Regional visitation totaling 3.0 million annual visits would generate annual welfare benefits of $30 million. Visitor expenditures associated with non-local visitation of approximately $124 million annually would support 1,490 annual jobs, $47 million in regional income, and $176 million in regional sales annually. For comparison, all economic activity in Region C supports 216,800 jobs, $10.3 billion in labor income, and $31.4 billion in sales annually.

**REGION D**

The region encompasses at least 215 access points on or near water that are managed by Federal and state agencies. Table 3-255 summarizes land ownership for protected lands located within 1 mile of the Columbia River in Region D, many of which are accessible to recreationists. The USFS manages the largest share of protected lands in this region, with USFWS and the Corps also managing a substantial share of lands. In addition to the Columbia River Gorge National Scenic Area, a portion of the Lewis and Clark National Historic Trail is in this region. Average visitation to sites within a mile of the river in Region D was estimated to be 6.7 million in 2017–2018. This analysis assumes that visitation would continue under the No Action Alternative.

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 Celilio, and Lake Bonneville. Regional visitation totaling 6.7 million annual visits would generate annual welfare benefits of $63 million. Visitor expenditures associated with non-local visitation of approximately $231 million annually would support 2,910 jobs, $127 million in regional income, and $394 million in regional sales. For context, all economic activity in Region D supports approximately 1.9 million jobs, $113.9 billion in labor income, and $330.4 billion in sales annually (IMPLAN 2017).

**SUMMARY OF EFFECTS**

Table 3-260 summarizes recreation conditions under the No Action Alternative for a typical year. Across the Basin, total recreational visitation at sites within 1 mile of the mainstem rivers, including water- and land-based use at reservoirs and river reaches, is anticipated to be approximately 13 million visits annually.[10] This recreational visitation is anticipated to support over $133 million in annual consumer surplus value (social welfare), primarily at CRS reservoirs.[11]

Visitor expenditures by non-local visitors are anticipated to be $499 million across the study area (as described in Section 3.11.3.2) annually under the No Action Alternative, with most of the expenditures occurring in Regions C and D. Regional economic effects associated with these expenditures on recreation in the Basin are anticipated to result in 6,480 annual jobs, $265 million in labor income, and $843 million in sales across the recreation study area annually. To put these numbers in context, across the Basin, all economic activity supports 2.9 million jobs, $163.0 billion in labor income, and $475.5 billion in sales annually. Recreational opportunities under the No Action Alternative would continue to support social well-being and quality of life, especially in the communities surrounding and adjacent to recreational sites. Sites in rural areas likely have a larger effect on local economic activity and community identity because there is less economic diversity and relatively higher reliance on local recreation-related businesses, 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.

**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 Koocanusa, Hungry Horse Reservoir, and Albeni Falls/Lake Pend Oreille. Regional visitation totaling 1.5 million visits would generate annual welfare benefits of $15 million.<br>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. | |

### *3.11.3.3 Multiple Objective Alternative 1*

MO1 includes operational changes to Libby, Hungry Horse, Grand Coulee, Dworshak, and John Day Dams. The anticipated changes in water surface elevations at Lake Koocanusa, Hungry Horse Reservoir, Lake Roosevelt, and Dworshak Reservoir could affect boat ramp accessibility for some periods of time during the year, and hence, access and visitation for some water-based visitors. Water quality and fishing conditions within reservoirs, as well as in some stream reaches below reservoirs, may also be affected under MO1. The effects of MO1 on recreation due to changes in the above resources are described for each region.

**SOCIAL WELFARE EFFECTS**

The focus of effects on water-based visitation in this section are described as annual effects that would occur after implementation of MO1. Over time, visitors may adjust their behavior to adapt to changes in accessibility and site quality, such as utilizing different sites on the system. These long-term adaptations could reduce effects that are reported in this section.

**Region A – Libby, Hungry Horse, and Albeni Falls Dams**

Under MO1, measures impacting recreation in Region A include a *Sliding Scale at Libby and Hungry Horse*, a single *December Libby Target Elevation*, and *Hungry Horse Additional Water Supply*. Because no structural measures are planned for Region A under MO1, the effect on recreation is directly tied to changes in water elevations and flows related to operational changes. These changes would be similar in the short term and longer term, over the 50-year period of analysis. However, as noted above, recreationists may adjust their behavior over time, which would reduce effects on visitation.

***Water-based Recreational Visitation***

Anticipated changes in water surface elevations under MO1 would affect boat ramp accessibility relative to the No Action Alternative at Lake Koocanusa (Libby Dam) and Hungry Horse Reservoir in Region A for some periods of time in a typical year. This change in accessibility would likely affect visitation to these sites. Changes in water levels at other reservoirs in the region would not affect accessibility and visitation. Due to changes in project outflows, recreational activities occurring in river reaches downstream of Libby Dam and Hungry Horse Dam could cause beneficial effects or adverse localized effects, or both, depending upon the river-based recreation activity.

At Lake Koocanusa, median water surface elevations would be higher for the majority of the year under MO1 relative to the No Action Alternative but would be lower by 2 to 3 feet on average March through May. The surface water elevations in March and April under MO1 would fall below the minimum usable elevations at some boat ramps, causing a decrease in boat ramp accessibility at the reservoir relative to the No Action Alternative. No accessibility effects are expected in May. Conversely, there would be increases in boat ramp accessibility in June and December due to higher median water surface elevations relative to the No Action

Alternative (there is very little recreation in January). Due to minor changes in boat ramp accessibility (both decreases and increases), water-based recreational visitation is estimated to decrease slightly (by less than 1 percent, approximately 234 visits) annually under MO1 relative to the No Action Alternative at Lake Koocanusa in a typical water year. In a high-water year (i.e., 25th percentile) water-based visitation would increase slightly (less than 0.2 percent) relative to the No Action Alternative high-water year. In a low-water year (i.e., 75th percentile), water-based visitation would increase slightly (less than 0.5 percent) relative to the No Action Alternative low-water year. In these years, any losses in visitation in some months would be offset by increases in visitation during other months.

At Hungry Horse Reservoir, median water surface elevations would be lower for the majority of the year under MO1 relative to the No Action Alternative, with declines of several feet on some days (see Appendix B, *Hydrology and Hydraulics*, for detail). The lower water surface elevations would result in decreased boat ramp accessibility in every month except July, August, and September. Because recreational visitation typically occurs between May and September at Hungry Horse, changes in boat ramp accessibility would lead to changes in water-based visitation in May and June only. Negligible to minor effects on recreational visitation are expected; water-based recreational visitation at Hungry Horse would decrease by approximately 1 percent (26 visits) annually in a typical year. Similar results would be expected in low- and high-water years. Changes in social welfare value associated with visitation changes at both Lake Koocanusa and Hungry Horse Reservoir would be negligible, about $3,000 in a typical year.

In addition to changes in reservoir elevations, river flows and stages in the region would change relative to the No Action Alternative. Increased occurrence of higher flows may create localized water turbidity and adversely affect nearby in-river recreational fishing activities. However, rafting and paddling activities may be beneficially affected. Both beneficial and adverse effects under MO1 are anticipated to be minor in river areas. The largest change in monthly median outflow from Libby Dam during peak recreation season is a decrease of 20 percent in May relative to the No Action Alternative. At Bonners Ferry, further down the Kootenai River, flows and stages would increase during several months, though the biggest changes in median conditions occur in winter months when visitation is low. Outflows from Hungry Horse Dam in the Flathead River would increase in the summer months, with the biggest changes of 21 percent in August and September. Smaller changes in river flows and stages (less than 10 percent) would occur elsewhere during peak recreation season in Region A under MO1.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be negligible in Region A under MO1. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, there would be some increased resident fish entrainment and reduced food supply at and downstream of Hungry Horse Dam in Region A, as well as a minor decrease in useable summer habitat in the mainstem Flathead River above Flathead Lake. However, the majority of fishing activity, which occurs in Flathead Lake, would be minimally affected. None of these changes would likely be noticeable to recreational anglers. Changes at Pend Oreille and in the Kootenai River would be minimal. No changes to recreation are anticipated on the Clark Fork River.

Lake Koocanusa (Libby Dam) would undergo changes in water surface elevations that could have a minor effect on water temperatures under MO1, but these changes would be minor and unlikely to impact the recreational use of the reservoir. It is possible that the operational changes proposed for MO1 may impact the nutrient levels in Lake Koocanusa, which could result in increased nuisance aquatic plant and algae growth during the growing season. These operational changes, however, are minor and only occur during more extreme water years (high/low water years) which likely would reduce the potential effects to recreational areas. Effects to recreation associated with changes in wildlife abundance are not anticipated in Region A under MO1.

**Region B – Grand Coulee and Chief Joseph Dams**

Grand Coulee operational measures include the *Lake Roosevelt Additional Water Supply* measure and various flood risk management operations such as decreasing the *Planned Draft Rate at Grand Coulee*, constraining *Grand Coulee Maintenance Operations*, and adding *Winter System FRM Space* to protect against rain-induced flooding. Chief Joseph operational measures include increased diversions for water supply (i.e., the *Chief Joseph Dam Project Additional Water Supply* measure). Because no additional measures are planned for Region B under MO1, the effect on recreation is directly tied to changes in water surface elevations and flows related to operational changes. These changes would be similar over the 50-year period of analysis. However, as noted above, recreationists may adjust their behavior over time, which would reduce effects on visitation.

***Water-based Recreational Visitation***

Anticipated changes in water surface elevations under MO1 would affect boat ramp accessibility at Lake Roosevelt in Region B relative to the No Action Alternative. Other reservoirs in the region would not be affected. Relative to the No Action Alternative, anticipated water surface elevations would be lower for the majority of the year, with the biggest median decreases occurring in winter months (where reservoir levels would drop 2 to 6 feet). Decreases during the peak recreation season months would be less than 1 foot on average in Region B under MO1. Decreases in boat ramp accessibility relative to the No Action Alternative are anticipated for most months. Decreases in accessibility are 2 percent or less, except in February when a 12 percent decrease in accessibility would occur. However, visitation is low during winter months.

Water-based visitation would decrease by less than 1 percent (approximately 6,000 visits) annually in a typical year. In a high-water year (i.e., 25th percentile) visitation would decrease by 3 percent when compared to a high-water year under the No Action Alternative. In a low-water year (i.e., 75th percentile), visitation would decrease by about 1.5 percent when compared to a low-water year under the No Action Alternative. Changes in social welfare value associated with the visitation change in a typical year would be about $91,000. A negligible to minor effect on water-based reservoir recreation is expected.

Changes in river flows and stages between dams would be minor (less than 10 percent) relative to the No Action Alternative and therefore would not be expected to affect river recreation.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be negligible in Region B under MO1. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, changes in instream survival of modeled anadromous fish species would be similar under MO1 to the No Action Alternative in Region B. Increased entrainment risk for some resident species and water elevation changes at the reservoir could increase stranding of kokanee and burbot eggs, which could adversely affect the destination fishery at Lake Roosevelt. These seem to be minor changes that would not likely be noticeable to most recreational anglers. In Region B, Lake Roosevelt would experience improved water clarity from the slower *Planned Draft Rate at Grand Coulee* under MO1, including reduced levels of total suspended solids and turbidity. While current water clarity is generally good at Lake Roosevelt, the improved water clarity could marginally improve the experience for picnickers, swimmers, boaters, and campers.

As described in Section 3.6, *Vegetation, Wildlife, Floodplains, and Wetlands*, under MO1 in Region B, decreased water surface elevations in the winter in Lake Roosevelt could have minor effects on predator populations, as well as ungulate populations in the Grand Coulee Dam area. Increasing the barren zone during the winter under lower water surface elevations could displace big game populations and provide increased area for mountain lion to hunt and kill prey animals around Lake Roosevelt. There could be some negligible to minor changes in the recreational experiences for hunters and wildlife viewers associated with these changes.

**Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams**

Under MO1, operational measures impacting recreation in Region C include the *Increased Forebay Range Flexibility* and *Modified Dworshak Summer Draft* measures. These changes would be similar over the 50-year period of analysis. However, as noted above, recreationists may adjust their behavior over time, which would reduce effects on visitation.

Structural measures impacting recreation in Region C include the *Additional Powerhouse Surface Passage*, *Upgrade to Adjustable Spillway Weirs*, *Lower Granite Trap Modifications*, and *Lower Snake Ladder Pumps* measures. The structural measures could have localized, short-term effects to recreation during the anticipated 2-year period when construction occurs in proximity to the recreation sites close to dams. Effects could include disruption at project sites, noise, potential traffic congestion, and access limitations during the construction period.

### *Water-Based Recreational Visitation*

Anticipated changes in water surface elevations under MO1 would affect boat ramp accessibility at Dworshak Reservoir in Region C relative to the No Action Alternative. Other reservoirs in the region would not be affected. Dworshak reservoir levels differ from the No Action Alternative in the summer months; median reservoir levels are 3 to 6 feet lower from late June through mid-August, and as much as 8 feet higher in September. As a result, there would be an anticipated decrease in boat ramp accessibility in August and an increase in September, but no changes to ramp accessibility in other months at Dworshak Reservoir.

Due to changes in boat ramp accessibility (both decreases and increases), water-based recreational visitation would be anticipated to decrease by less than 1 percent (approximately 1,000 visits) annually in a typical year. In a high-water year (i.e., 25th percentile) water-based visitation would increase by less than 1 percent. In a low-water year (i.e., 75th percentile), water-based visitation would decrease by about 1.3 percent. Reductions in social welfare associated with the visitation change in a typical year are anticipated to be about $13,000.

In addition to changes in reservoir elevations, river flows and stages in the region would change relative to the No Action Alternative. These changes could affect in-river activities like fishing, rafting, and paddling. While beneficial and adverse effects under MO1 are anticipated to be minor in most river areas, they could be major in some cases. Changes to flows and stages along the Clearwater River below Dworshak Dam occur in the summer. Specifically, median monthly outflows from Dworshak and at the Spalding gage would decrease by 51 and 42 percent, respectively, in August and increase in September by 97 and 71 percent, respectively. This may change the timing and quality of recreation in the Clearwater River, particularly fishing (e.g., trout, whitefish), due to increased turbidity, which is most popular in that stretch according to a Corps resource manager at Dworshak (Corps 2019). If recreationists are unable to adapt to these changes along the Clearwater River, moderate social welfare effects could occur in August and September. At the Clearwater and Snake River confluence and Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams, flows would decrease by 16 to 17 percent in August. These changes in flows may affect recreation near the dams, but likely not in the broader reservoirs. Smaller changes in river flows and stages (less than 10 percent) would occur elsewhere during peak recreation season in Region C.

### *Quality of Recreational Experience*

Changes in the quality of recreational experience are anticipated to be negligible to minor and adverse in Region C under MO1. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, returns of salmon and steelhead would be similar to the No Action Alternative in Region C. Minor increases in median abundance of Snake River spring-run Chinook salmon would occur in the middle and south forks of the Salmon River (tributaries to the Snake River upstream from Lewiston, Idaho). Likewise, resident fish in the lower Snake River reservoirs would see minor effects under MO1 but populations would be similar to the No Action Alternative. These seem to be minor changes that would not likely be noticeable to most recreational anglers. Given this, negligible changes in recreational fishing related to changes in fish populations are anticipated under MO1 relative to the No Action Alternative.

In Region C, MO1 would cause cooler water temperatures in June, July, and September, and warmer temperatures in August. Warmer water temperatures may make summer recreation more enjoyable for people who prefer warmer water for rafting and boating. Due to warmer water temperatures, however, the river stretch between Lower Granite and Ice Harbor Dams could experience increased algae blooms and higher coliforms and other microbes in embayments and swim beaches. August is one of the most popular months for water recreationists, so this may diminish the quality of the recreation experience in this stretch of river during this time of year and lead to health and safety concerns.

As described in Section 3.6, *Vegetation, Wildlife, Floodplains, and Wetlands*, in Region C, the wildlife and vegetation conditions along the lower Snake River would be similar under MO1 as under the No Action Alternative. As such, changes to recreation associated with changes to wildlife are not anticipated in Region C under MO1.

**Region D – McNary, John Day, The Dalles, and Bonneville Dams**

Under MO1, operational measures impacting recreation in Region D include the *Increased Forebay Range Flexibility* measure and the *Predator Disruption Operations* measure. Structural measures impacting recreation in Region D include the *Improved Fish Passage Turbines*, *Additional Powerhouse Surface Passage*, and *Modify Bonneville Ladder Serpentine Weir* measures. Similar to Region C, structural measures included for Region D projects could have localized, short-term effects to recreation during the anticipated 2-year period when construction occurs in proximity to the recreation sites close to dams. Effects could include disruption at project sites, noise, potential traffic congestion, and access limitations during the construction period.

***Water-based Recreational Visitation***

Changes in water surface elevations and river flows are expected to be sufficiently minor as not to affect recreational access and visitation at recreation sites at the four reservoirs and river reaches in Region D.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be negligible in Region D under MO1. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, changes in instream survival of modeled resident fish species are not anticipated to be statistically different under MO1 when compared to the No Action Alternative in Region D. Minor increases in median abundance of Snake River spring-run Chinook and steelhead are anticipated from the mouth of the Snake River to Bonneville Dam. Minor changes in median abundance of upper Columbia River spring-run Chinook (increase) and steelhead (decrease) are also anticipated from the mouth of the Snake River to Bonneville Dam. These changes are likely not enough to change recreational fishing conditions. As such, no changes in recreational fishing are anticipated under MO1 relative to the No Action Alternative.

Between Ice Harbor and McNary Dams, MO1 would result in cooler water temperatures in June, July, and September, and warmer temperatures in August. The warmer August waters could result in increased algal blooms, and increased coliforms and other microbes in embayments and swim beaches, as compared to the No Action Alternative. August is one of the most popular months for water recreationists, so this may diminish the quality of the recreation experience in this stretch of river during this time of year and lead to health and safety concerns. Downstream of McNary Dam, negligible effects to water quality are anticipated under MO1.

Negligible to minor changes in vegetation and habitat conditions for wildlife are anticipated in Region D under MO1. Approximately 4 acres of nesting habitat for waterbirds may be inundated during April and May in Lake Umatilla; the delay in availability of nesting habitat has some potential to affect the overall reproductive success of these birds. However, these changes are not anticipated to substantially affect populations in a manner that would be readily observable to recreationists or hunters. Other wildlife populations are not anticipated to be affected under this alternative. As such, negligible changes in recreation associated with changes in wildlife abundance are anticipated in Region D under MO1.

**REGIONAL ECONOMIC EFFECTS**

As a result of changes in boat ramp accessibility, recreational expenditures associated with non-local visitation at Lake Koocanusa and Hungry Horse in Region A would decrease annually by $12,000 under MO1. Recreational expenditures associated with non-local visitation at Lake Roosevelt in Region B would decrease annually by $235,000 under MO1. Recreational expenditures associated with non-local visitation at Dworshak Reservoir in Region C would decrease annually by $54,000 under MO1. Additional regional economic effects, particularly around Orofino, could occur due to large changes in flows along the Clearwater River in August and September during typical years. No changes to visitation are anticipated in Region D under MO1 relative to the No Action Alternative. These changes represent less than 1 percent of non-local recreational expenditures in the Basin under the No Action Alternative. Overall, the change in regional expenditures and the regional economic implications of those changes would be negligible to minor, resulting in approximately 4 fewer jobs, $139,000 less in labor income, and $404,000 less in sales. Over time, visitors would likely adjust their behavior to adapt to the minor anticipated changes in accessibility, such as utilizing different sites on the system. These long-term adaptations would reduce effects to visitation.

**OTHER SOCIAL EFFECTS**

Because of the modest anticipated changes to visitation described in the social welfare evaluation and the minor improvements to fish populations anticipated under MO1, changes in other social effects are not anticipated under MO1. A localized exception may exist along the Clearwater River in Region C where major social effects could occur to recreational anglers who could be displaced by changes in outflows and increased turbidity from Dworshak Dam in August and September under MO1.

**SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 1**

Overall effects of MO1 on recreational visitation are anticipated to be negligible to minor, with the exception of moderate adverse effects to recreational fishing in the Clearwater Reach below Dworshak Dam in August and September. Table 3-261 presents a summary of MO1 effects, including the anticipated changes in average annual recreational visitation, social welfare, and regional economic effects by region and in total relative to the No Action Alternative. For a comparison of anticipated social welfare and regional economic effects across alternatives refer to Table 41 in Appendix M. Across the Basin, total recreational visitation and associated social welfare effects are anticipated to decrease by less than 1 percent annually (approximately 7,500 visits and $107,000) in a typical year associated with changes in boat ramp access. Expenditures associated with non-local visitation would decrease by $300,000 annually across the region, a change of 0.1 percent compared to the No Action Alternative. Regional economic effects of this change in expenditures would be negligible. The largest reservoir effects are anticipated at Lake Roosevelt in Region B, the most visited of the four reservoirs.

There would be negligible to minor benefits to fish populations. Effects to the quality of fishing, hunting, wildlife viewing, swimming, and water sports at river recreation sites in the region under MO1 would be negligible. However, 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.

Over time, visitors may adjust their behavior to adapt to changes in accessibility and site quality, such as utilizing different sites on the system. These long-term adaptations could reduce effects to visitation.

**Table 3-261. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 1 Relative to the No Action 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 Koocanusa 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 |

| Region | Social Welfare Effects (2019 dollars) | Regional Economic Effects (2019 dollars) | Other Social Effects |
|---|---|---|---|
| Total | 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.<br>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. | 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). | 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. |

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### *3.11.3.4 Multiple Objective Alternative 2*

MO2 includes substantial operational changes to Libby, Hungry Horse, and Grand Coulee Dams, as well as some changes to operations at the lower Snake and lower Columbia River projects. The anticipated changes in water surface elevations at Lake Koocanusa, Hungry Horse Reservoir, Lake Roosevelt, and Dworshak Reservoir are anticipated to affect boat ramp accessibility for some periods of time during the year, and hence, access and visitation for some water-based visitors. Water quality and fishing conditions within reservoirs as well as in some stream reaches below reservoirs may also be affected under MO2. The effects of MO2 on recreation due to changes in the above resources are described for each region.

**SOCIAL WELFARE EFFECTS**

The focus of effects on water-based recreational visitation in this section are described as annual effects that would occur after implementation of MO2. Over time, visitors may adjust their behavior to adapt to changes in accessibility and site quality, such as utilizing different sites on the system. These long-term adaptations could reduce reported effects.

**Region A – Libby, Hungry Horse, and Albeni Falls Dams**

Under MO2, measures impacting recreation in Region A include Modifying Draft at Libby, establishing a single *December Libby Target Elevation*, and implementing a *Sliding Scale at Libby and Hungry Horse*. The Libby and Hungry Horse projects would be operated based on local water supply conditions to allow water managers more flexibility to balance local resident fish priorities in the upper basin with downstream flow augmentation. In addition, Libby, Hungry Horse, and Albeni Falls would be operated with slightly more flexibility for hydropower generation by relaxing restrictions on seasonal pool elevations at the storage projects. Libby would also be operated to improve reservoir space to balance local and system FRM needs, temperature management, and operational flexibility for releases in the spring and summer.

No construction activities would occur in Region A under MO2. Therefore, the effects to recreation in the short term would be similar to the longer-term effects described in the sections below.

***Water-based Visitation***

Anticipated changes in water surface elevations under MO2 would affect boat ramp accessibility relative to the No Action Alternative at Lake Koocanusa (Libby Dam) and Hungry Horse Reservoir in Region A for some periods of time in a typical year. This change in accessibility could affect visitation to these sites. Changes in water levels at other reservoirs in the region would not affect accessibility and visitation. Due to changes in project outflows, recreational activities occurring in river reaches downstream of Libby Dam and Hungry Horse Dam could cause both beneficial or adverse localized effects, or both depending upon the river recreation activity.

At Lake Koocanusa, median water surface elevations would be lower for the majority of the year under MO2 relative to the No Action Alternative, with the largest decreases in December and January, when the median decreases are about 12 and 10 feet, respectively. However, the largest decreases in accessibility would occur in March and April, when median water surface elevations decrease by about 3 and 2 feet, respectively. Almost 80 percent of visitation to Lake Koocanusa occurs from May to September, when there are no changes in accessibility under MO2 relative to the No Action Alternative. Changes in boat ramp accessibility during other months would reduce water-based visitation by less than 1 percent (approximately 316 visits) annually in a typical water year. In a high-water- year (i.e., 25th percentile) annual water-based visitation would decrease slightly (less than 0.4 percent) relative to the No Action Alternative high-water year. In a low-water year (i.e., 75th percentile), annual water-based visitation would increase slightly (less than 0.5 percent) relative to the No Action Alternative low-water year.

At Hungry Horse Reservoir, median water surface elevations would be lower for the first 6 months of the year under MO2 relative to the No Action Alternative, with monthly decreases as large as 8 feet relative to the No Action Alternative. The lower water surface elevations would result in decreased boat ramp accessibility in January to June at Hungry Horse Reservoir. However, changes in accessibility in January to April would not be expected to result in changes in visitation because most visitation occurs between May and September at Hungry Horse. Water-based visitation at Hungry Horse would decrease by approximately 1 percent (21 visits) annually in a typical year, which would also occur in high- and low-water-level years. Changes in social welfare value associated with visitation changes at both sites would be about $3,500 in a typical year.

In addition to changes in reservoir elevations, river flows and stages in the region would change relative to the No Action Alternative. Increased occurrence of higher flows may create localized water turbidity and adversely affect nearby in-river recreational fishing activities. However, rafting and paddling activities may be beneficially affected. Both positive and adverse effects under MO2 are anticipated to be minor in river areas. The largest change in monthly median outflow from Libby Dam during peak recreation season is a decrease of 30 percent in May relative to the No Action Alternative. At Bonners Ferry, further down the Kootenai River, flows and stages change most in winter months when visitation is low. Outflows from Hungry Horse and SKQ Dams in the Flathead River would be unchanged in summer months except in June when median outflows decrease by 71 percent at Hungry Horse and 10 percent at SKQ Dam. Smaller changes in river flows and stages (i.e., less than 10 percent) would occur elsewhere during peak recreation season in Region A under MO2.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be minor in Region B under MO2. Higher flows and reduced reservoir elevations at Hungry Horse Dam/Reservoir could lead to reductions in zooplankton and other food sources, impacting resident fish populations under MO2. Fish populations could also be affected by increased entrainment and greater exposure to predation and angling during upstream spawning migrations. Winter flows in the South Fork

Flathead River below Hungry Horse would be roughly double what they would under the No Action Alternative, resulting in reduced habitat and more difficult fishing conditions because of high velocities. Implementation of MO2 at Hungry Horse Dam on the Flathead River may lead to an increased exposure of wildlife to predation when the reservoir is drawn down, which may have minor adverse effects to recreational hunting and viewing of wildlife species.

Implementation of MO2 at Albeni Falls Dam (Lake Pend Oreille) would result in changes to elevation on the Pend Oreille River downstream of the dam, which would have minor adverse effects on vegetation and nesting habitat available to aquatic and terrestrial wildlife. However, shorebirds would benefit from increased foraging habitat availability on exposed mudflats.

Resident fish species may be adversely impacted from higher winter flows anticipated under MO2 downstream of Libby Dam. These higher flows could reduce zooplankton productivity (food availability for fish) and impact the natural cooling of the river downstream of Libby Dam in early winter. MO2 measures could also shift the nutrient levels in Lake Koocanusa (Libby Dam), which could result in increased nuisance aquatic plant and algae growth during the growing season. If substantial changes in aquatic plant growth and algal blooms occurs, this could make Lake Koocanusa less attractive to recreationists and lead to health and safety concerns, especially to those interested in swimming and water sports. June flows under MO2 would reduce fish habitat and would likely reduce recruitment below Hungry Horse. Productivity would also be reduced as the stream would be so low that it would leave cobble and gravel areas that produce insects dry.

The vegetation, wetland, and wildlife analyses found that changes in water surface elevations at Lake Koocanusa under MO2 would adversely affect waterbird populations, which could result in minor adverse effects to wildlife viewing opportunities. Conversely, more island habitats for waterbird nesting would be available at Lake Koocanusa and might increase bird-watching recreation opportunities.

In addition, reduced spring freshet would reduce sturgeon habitat on the Kootenai River in Region A. The lowered pool elevations at Libby Dam may also allow suspended solids to move downstream and increase the level of total suspended solids in downstream river areas, which could result in adverse effects to recreational fishing conditions on the Kootenai River. River flows on the Kootenai River would be higher in the winter, increasing erosion of the shoreline, and reducing the area of riparian regeneration and productivity of the aquatic system. Effects could result in some displacement of wildlife populations that are dependent on forested wetland habitats.

**Region B – Grand Coulee and Chief Joseph Dams**

Under MO2, measures impacting recreation in Region B include constraining *Grand Coulee Maintenance Operations* and decreasing the *Planned Draft Rate at Grand Coulee*. Grand Coulee would be managed to improve safety, reliability, and capacity of the power plant and spillway. *Winter System FRM Space* at Grand Coulee would also be operated to preserve the ability to operate the reservoirs for FRM purposes. In addition, Grand Coulee and Chief Joseph would be operated with slightly more flexibility for hydropower generation due to *Slightly Deeper Draft for Hydropower* to meet fluctuations in demand.

No construction activities would occur in Region B under MO2. Therefore, the effects to recreation in the short term would be similar to the longer-term effects described in the sections below.

***Water-based Visitation***

Anticipated changes in water surface elevations under MO2 would affect boat ramp accessibility at Lake Roosevelt in Region B relative to the No Action Alternative. Other reservoirs in the region would not be affected. Relative to the No Action Alternative, anticipated water surface elevations would be lower for most of the year, especially in December through March. In those months, median water surface elevations would decrease by as much as 5 feet at some locations. Changes in water elevations in April through November, when over 85 percent of visitation occurs, would not exceed 1.5 feet. While decreased boat ramp accessibility would occur at Lake Roosevelt, it would only result in minor changes in visitation because accessibility effects would not occur during the peak recreation season.

Due to changes in boat ramp accessibility, water-based recreational visitation would decrease by less than 1 percent (approximately 7,700 visits) annually in a typical year. In a high-water year (i.e., 25th percentile), visitation would decrease by about 1.6 percent. In a low-water year (i.e., 75th percentile), visitation would decrease by about 3.4 percent. Changes in social welfare value associated with the visitation change in a typical year would be about $115,000. Changes in river flows and stages between dams would be minor relative to the No Action Alternative (i.e., changes in flow would be less than 10 percent) and therefore would result in negligible effects to river recreation.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be minor in Region B under MO2. There are a number of possible effects to the quality of the recreational experience from operational measures at the reservoirs and the river reaches from changes in reservoir elevations and river flows and associated water quality, water temperatures, and bird, wildlife, and fish habitats in Region B.

As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, upper Columbia spring Chinook salmon and steelhead would demonstrate reductions in biological performance metrics compared to the No Action Alternative under MO2, including a minor decrease in abundance. Reductions in anadromous fish populations could adversely affect recreational conditions in Region B under MO2. In Lake Roosevelt resident fish, increased entrainment risk for some species (bull trout, kokanee, rainbow trout, burbot) and changes in tributary access for trout spawning could adversely affect the destination fishery at Lake Roosevelt.

Lake Roosevelt would experience some improved water clarity from the slower *Planned Draft Rate at Grand Coulee* under MO2 in Region B, including reduced levels of total suspended solids and turbidity. While current water clarity is generally good at Lake Roosevelt, the improved water clarity could marginally improve the recreational experience for picnickers, swimmers, boaters, and campers. Changes to other water quality conditions that would affect recreation are not anticipated in Region B under MO2. Lake Roosevelt would experience negligible changes to wildlife during the growing season. During the winter, lower water surface elevations may decrease open water habitat and access to aquatic vegetation for foraging loons and other waterfowl. Additionally, there would be some impact to predator-prey relationships; bighorn sheep and deer would be at a greater risk to mountain lion and wolf populations. Slightly lower populations of deer and other ungulates could have some minor adverse effects on hunting conditions in this area.

**Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams**

Within Region C, measures included under MO2 are focused on both structural and operational changes to the projects. Structural measures occur at the four lower Snake River projects, while only operational measures would occur at Dworshak. All five of the projects in Region C would be operated with slightly more flexibility for hydropower generation due to *Full Range Reservoir Operations*, *Slightly Deeper Draft for Hydropower*, and *Full Range Turbine Operations* measures. Operational measures would also occur at the Lower Snake River projects to limit *Spill to 110% TDG* and *Increase Juvenile Fish Transportation*. Like in Regions A and B, these changes would be similar over the 50-year period of analysis, with the bulk of the effects occurring at Dworshak Reservoir. However, as noted above, recreationists may adjust their behavior over time, which would reduce effects on visitation.

At all four lower Snake River projects, the *Turbine Strainer Lamprey Exclusion* measures would be installed. At Little Goose and Lower Granite projects, the *Bypass Screen Modifications for Lamprey* measure would be used to prevent lamprey impingement. Three of the Lower Snake River projects (Lower Granite, Lower Monumental, and Ice Harbor) would Upgrade to Adjustable Spillway Weirs for greater operational flexibility to improve juvenile salmon and steelhead survival. At Ice Harbor, Additional Powerhouse Surface Passage would be constructed to increase juvenile salmon and steelhead fish passage survival. In addition, *Fewer Fish Screens* would be installed at Ice Harbor, increasing the efficiencies of hydropower turbines. *Lower Snake Ladder Pumps* would be installed to provide cooler water for adult fish ladders at Lower Monumental and Ice Harbor Dams.

Similar to MO1 Region C, construction of the structural measures at the four lower Snake River projects could have minor, localized, short-term effects to recreation during the anticipated 2-year period when construction occurs in proximity to the recreation sites close to the dams. Effects could include disruption at project sites, noise, potential traffic congestion, and access limitations during the construction period.

### *Water-based Visitation*

Anticipated changes in water surface elevations under MO2 would affect boat ramp accessibility at Dworshak Reservoir in Region C. Other reservoirs in the region would not be affected. Relative to the No Action Alternative, anticipated median water surface elevations would decrease by 8 to 26 feet from January to May, 6 feet in June, 4 feet in July, and 2 feet or less the rest of the year. As a result, decreased boat ramp accessibility would occur from January to May, reducing accessibility by approximately 10 to 30 percent relative to the No Action Alternative. Accessibility effects are negligible in other months.

Four of the seven analyzed boat ramps (Bruce's Eddy 1 and 2, Canyon Creek, and Grandad) are projected to lose 2 to 6 days of accessibility under MO2, while Freeman Boat Ramp at Dworshak State Park, one of the more popular ramps at the reservoir, would experience the greatest adverse effects. The ramp would become inaccessible from mid-January to early May (when about one-third of visits occur at the reservoir) relative to the No Action Alternative, losing a total of 102 accessible days.

Due to changes in boat ramp accessibility at Dworshak Reservoir, water-based recreational visitation would decrease by 6.5 percent (approximately 12,000 visits) annually in a typical year compared to the No Action Alternative. In a high-water year (i.e., 25th percentile) visitation would decrease by about 4.2 percent. In a low-water year (i.e., 75th percentile), visitation would decrease by about 7.0 percent. Changes in social welfare value associated with the visitation change in a typical year would be approximately $135,000.

In addition to these quantified effects for water-based recreation, lower water levels may affect non-water activities through changes in aesthetics, landscape (e.g., increased size of sandy beach areas), and other factors. For example, there may be adverse effects to campgrounds primarily accessed by boat under MO2. Based on conversations with a recreational manager in the area, accessibility and subsequent visitation to boat-in camp sites typically declines to near zero when water elevations are below 1,570 feet and declines to a lesser extent when water levels are below 1,585 feet. Under MO2, there are six additional days when water levels fall below these thresholds relative to the No Action Alternative, all during peak recreation season (early June).

In addition to changes in reservoir elevations, river flows and stages in the region would change relative to the No Action Alternative. However, the largest changes in the region occur in winter months when recreation is low. In summer months, flows and stages would change by less than 10 percent, except on the North Fork of the Clearwater River (below Dworshak Dam) where median monthly flow would decrease by 46 percent in June. These changes could affect in-river activities like fishing, rafting, and paddling, though positive and adverse effects under MO2 are anticipated to be minor in river areas. Minor changes in river flows and stages (i.e., less than 10 percent) would occur elsewhere during peak recreation season in Region C under MO2.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be minor in Region C under MO2. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, changes in instream survival of modeled anadromous fish species would generally decrease under MO2 when compared to the No Action Alternative in Region C. Decreases in median abundance of Snake River spring-run Chinook would occur. Decreases of in-river survival of Snake River steelhead are also anticipated. Kokanee in Dworshak Reservoir would be somewhat reduced by increased entrainment, which could impact recreational fishing. These changes may not be noticeable to anadromous anglers; these already-rare fish would be somewhat more rare. As such, effects to recreational fishing are anticipated to be minor under MO2 relative to the No Action Alternative related to changes in fish populations in Region C.

In Region C, MO2 would result in negligible changes to water temperatures in river and reservoir areas between Lower Granite Dam and McNary, with some minor warming in the summer under the driest of water years.

As described in Section 3.6, *Vegetation, Wildlife, Floodplains, and Wetlands*, implementing MO2 would likely result in negligible to minor changes to hunting and wildlife habitat and viewing opportunities in Region C.

**Region D – McNary, John Day, The Dalles, and Bonneville Dams**

Similar to Region C, MO1 measures for Region D include operational measure and several structural measures at the four lower Columbia River projects. All four of the projects in region D would be operated with more flexibility for hydropower generation due to the *Slightly Deeper Draft for Hydropower* and *Full Range Turbine Operations* measures. Changes under MO2 also limit *Spill to 110% TDG* to better meet power demand. Like in Regions A, B, and C, these changes would be similar over the 50-year period of analysis. However, as noted above, recreationists may adjust their behavior over time, which would reduce effects on visitation.

Structural measures included for Region D projects include installing *Improved Fish Passage Turbines* at John Day; constructing a surface passage route for fish at McNary and John Day; *Upgrading to Adjustable Spillway Weirs at John Day and McNary*; *Modifying Bypass Screen for Lamprey* at McNary to prevent lamprey impingement; and expanding *Lamprey Passage Structures* at Bonneville, The Dalles, and John Day. *Turbine Strainer Lamprey Exclusion* and *Lamprey Passage Ladder Modifications* would be implemented at all four Lower Columbia River projects.

Similar to MO1 Region D, construction of the structural measures at the four Lower Columbia River projects could have minor, localized, short-term effects to recreation during the 2-year period when construction occurs in proximity to the recreation sites close to the dams. Effects could include disruption at project sites, noise, potential traffic congestion, and access limitations during the construction period.

***Water-based Visitation***

Changes in water surface elevations and river flows are expected to be negligible and would not affect recreational access and visitation at recreation sites at the four reservoirs as well as at river reaches in Region D under MO2.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be negligible to minor in Region D under MO2. Under MO2, decreased abundance of Snake River spring Chinook and Snake River steelhead, upper Columbia River spring Chinook, and decreased in-river survival rates of upper Columbia River steelhead would adversely affect recreational fishing conditions on the Columbia River in Region D.

Above McNary Dam in the Snake River, MO2 would result in negligible to minor increases in water temperatures in the summer. These increased water temperatures could lead to increased frequency of algae blooms and increased levels of coliforms and other microbes in embayments and at swim beaches. August is one of the most popular months for recreation, so this may diminish the quality of the recreation experience in this stretch of river during this time of year.

Similar to MO1, minor changes in vegetation and habitat conditions for wildlife are anticipated in Region D under MO2. Some nesting habitat for waterbirds may be inundated during April and May in Lake Umatilla; the delay in availability of nesting habitat has some potential to affect the overall reproductive success of these birds. However, these changes are not anticipated to affect populations in a manner that would be readily observable to recreationists or hunters. Other wildlife populations are not anticipated to be affected under this alternative. As such, no changes in recreation associated with changes in wildlife abundance are anticipated in Region D under MO2.

**REGIONAL ECONOMIC EFFECTS**

As a result of changes in boat ramp accessibility, recreational expenditures associated with non-local visitation at Lake Koocanusa and Hungry Horse in Region A would decrease annually by $15,000 under MO2 associated with changes in boat ramp access. Recreational expenditures associated with non-local visitation at Lake Roosevelt in Region B would decrease annually by $297,000 under MO2. Recreational expenditures associated with non-local visitation at Dworshak Reservoir in Region C would decrease annually by $549,000 under MO2. Because most changes in visitation would occur along the southern portion of Dworshak Reservoir (at Freeman Creek boat launch, in particular) communities reliant on recreation in that area—including Orofino—could be adversely affected in Region C. No changes to visitation are anticipated in Region D under MO2 relative to the No Action Alternative. Overall, minor regional economic effects would occur due to changes in non-local visitor expenditures across the Basin, resulting in approximately 11 fewer jobs, $434,000 less in labor income, and $1.3 million less in sales. Most of these effects would be concentrated in Region C. As with social welfare effects, these effects would likely result in the short term, and may be reduced over time as visitors adjust behavior. If recreationists reduce recreation trips to this region due to reduced quality of recreation experiences, additional effects could occur.

**OTHER SOCIAL EFFECTS**

Recreation would continue to provide other social effects associated with considerable recreational opportunities in the region under MO2. Continued operation of the system would provide benefits to community well-being, cohesion, and identity associated with existing recreational activities. Because most changes in visitation would occur along the southern portion of Dworshak Reservoir (at Freeman Creek boat launch, in particular) communities reliant on recreation in that area—including Orofino—could be adversely affected by decreased reservoir access. However overall, changes in access to recreation sites would be minor under MO2. Under MO2 adverse effects to fish species would have adverse effects on the well-being of those recreationists who value these fish, particularly area tribes.

**SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 2**

Overall effects of MO2 on recreation are anticipated to be minor in the short and long term following implementation. Table 3-262 presents a summary of MO2 effects, including the anticipated changes in average annual recreational visitation, social welfare, and regional economic effects by region and in total relative to the No Action Alternative. For a comparison of anticipated social welfare and regional economic effects across alternatives refer to Table 41 in Appendix M. Across the Basin, total visitation and associated social welfare effects are anticipated to decrease by less than 1 percent (0.2 percent) annually in a typical year (approximately 20,000 visits and $253,000) under MO2. Expenditures associated with non-local recreational visits would decrease by $861,000 across the Basin. The total economic effects of this change in regional expenditures would be minor. The largest effects are anticipated at Dworshak Reservoir in Region C, the second-most visited of the four reservoirs that are anticipated to have effects on boat ramp accessibility.

Resident fish entrainment would increase in Region A, which could result in minor effects in the quality of fishing experiences there. In addition, decreases in fish abundance for several anadromous fish species could result in minor effects in recreational fishing experiences under MO2 in Regions B, C, and D. There would be additional minor adverse effects associated with increased algal bloom frequency in some areas, as well as effects to wetlands and waterbird habitat that could adversely affect wildlife viewing, and swimming at reservoir and river recreation sites in the region under MO2. If recreationists reduce recreation trips to this region due to declines in recreation experiences, additional effects could occur.

**Table 3-262. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 2 Relative to the No Action Alternative**

| Region | Social Welfare Effects (2019 dollars) | Regional Economic Effects (2019 dollars) | Other Social Effects |
|---|---|---|---|
| Region A | 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 Koocanusa 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.<br>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. | 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. | Minor decrease in water-based recreation visitor days causing slight reduction in well-being of reservoir recreationist.<br>Potential adverse impacts to fish species could decrease recreational fishing opportunity and reduce well-being of recreationists who value fishing, as well as tribes. |
| Region B | 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.<br>Decreases in fish abundance for several anadromous fish species could adversely affect recreational fishing experiences below Chief Joseph Dam. | 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. | Decreased water-based recreation access at Lake Roosevelt could have adverse effects on recreationists.<br>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. |

| Region | Social Welfare Effects (2019 dollars) | Regional Economic Effects (2019 dollars) | Other Social Effects |
|---|---|---|---|
| Region C | 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.<br>Decreases in fish abundance for several anadromous fish species could adversely affect recreational fishing experiences.<br>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. | 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. | 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.<br>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. |
| Region D | 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.<br>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. | 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. | No change in boat ramp access. Potential adverse impacts to fish species could decrease recreational fishing opportunity and fishing recreationists' well-being. |

| 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.<br>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. |

### *3.11.3.5 Multiple Objective Alternative 3*

MO3 would include substantial operational changes to Libby, Hungry Horse, and Grand Coulee Dams, and smaller changes to operations on the lower Columbia along with the dam breaches at the four lower Snake River projects. The effects of MO3 on recreation from changes in these structural and operational measures are described for each region.

**SOCIAL WELFARE EFFECTS**

The effects on recreational visitation in this section are described as annual effects in both the short term during and after breaching and construction activity as well as in the longer term when natural river conditions have been established.

**Region A – Libby, Hungry Horse, and Albeni Falls Dams**

Within Region A, measures included under MO3 are focused on operational changes to the projects and do not include structural modifications or additions. The Libby and Hungry Horse projects would be operated based on a Sliding Scale for summer drafts to allow water managers more flexibility to balance local resident fish priorities in the upper basin with downstream flow augmentation. Hungry Horse Reservoir would include Additional Water Supply managed to store and release water downstream for the Confederated Salish and Kootenai Tribe water rights for irrigation and municipal and industrial purposes. In addition, Libby, Hungry Horse, and Albeni Falls would be operated with slightly more flexibility for hydropower generation by relaxing restrictions on seasonal pool elevations at the storage projects. Libby would also be operated to improve reservoir space to balance local and system FRM needs, temperature management, and operational flexibility.

No construction activities would occur in Region A under MO3. Therefore, the effects to recreation in the short term would be similar to the longer-term effects described in the sections below.

***Water-Based Visitation***

Anticipated changes in water surface elevations under MO3 would affect boat ramp accessibility relative to the No Action Alternative at Lake Koocanusa (Libby Dam) and Hungry Horse Reservoir in Region A for some periods of time in a typical year. Changes in water levels at other reservoirs in the region would not affect accessibility and visitation. Due to changes in project outflows, recreational activities occurring in river reaches downstream of Libby Dam and Hungry Horse Dam could cause beneficial or adverse localized effects, or both, depending upon the river-based recreation activity.

At Lake Koocanusa, median water surface elevations under MO3 would be the same as under MO2. These water level changes would affect boat ramp accessibility and reduce water-based visitation by a small amount (less than 1 percent, or approximately 316 visits annually) in a typical water year relative to the No Action Alternative. In a high-water year (i.e., 25th percentile) annual water-based visitation would decrease slightly (less than 0.4 percent) relative to the No Action Alternative high-water year. In a low-water year (i.e., 75th percentile), annual water-based visitation would increase slightly (less than 0.5 percent) relative to the No Action Alternative low-water year.

At Hungry Horse Reservoir, median water surface elevations would be lower for the majority of a typical year under MO3 relative to the No Action Alternative, with daily decreases of up to 7 feet relative to the No Action Alternative. The lower water surface elevations would result in decreased boat ramp accessibility in every month except July, August, and September when decreased water levels are small enough not to affect accessibility. Because recreational visitation typically occurs between May and September at Hungry Horse, changes in boat ramp accessibility would mostly affect water-based visitation in May and June. Negligible to minor effects on recreational visitation are expected. Water-based recreational visitation at Hungry Horse would decrease by approximately 1.3 percent (29 visits) in a typical year. Decreases in water-based visitation would be less than 1 percent in low- and high-water-level years. Changes in social welfare value associated with visitation changes under MO3 in a typical year at both reservoirs would be about $3,600 lower than the No Action Alternative.

In addition to changes in reservoir elevations, river flows and stages in the region would change relative to the No Action Alternative. Increased occurrence of higher flows may create localized water turbidity and adversely affect nearby river-based fishing activities. However, rafting and paddling activities may be positively affected. Both positive and adverse effects under MO3 are anticipated to be minor in river areas. The largest change in monthly median outflow from Libby Dam during peak recreation season is a decrease of 30 percent in May relative to the No Action Alternative. At Bonners Ferry, further down the Kootenai River, flows and stages would decrease during most months, though biggest changes occur in winter months when visitation is low. Outflows from Hungry Horse Dam in the Flathead River would change most during summer months, with a decrease of 10 percent in May and an increase of 21 percent in August and September. Smaller changes in river flows and stages (less than 10 percent) would occur elsewhere during peak recreation season in Region A under MO3.

#### ***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be negligible in Region A under MO3. Similar to MO1, as described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, there could be some increased resident fish entrainment and reduced food supply at and downstream of Hungry Horse Dam in Region A under MO3. In addition, high summer flows would reduce native fish habitat in the Flathead River below Flathead Lake. However, the majority of fishing activity, which occurs in Flathead Lake, would be minimally affected. None of these changes seem likely to be noticeable to recreational anglers. Changes at Pend Oreille and in the Kootenai River would be minimal. No changes to recreation are anticipated on the Clark Fork River.

Lake Koocanusa (Libby Dam) would undergo changes in water surface elevations that could have a minor effect on water temperatures under MO3, but these changes would be minor and unlikely to impact the recreational use of the reservoir. It is possible that the operational changes proposed for MO3 may impact the nutrient levels in Lake Koocanusa, which could result in increased nuisance aquatic plant and algae growth during the growing season. These operational changes, however, are minor and only occur during more extreme water years (high/low water years) which likely would reduce the potential effects to recreational areas. If substantial changes in aquatic plant growth and algal blooms occurs, this could make Lake Koocanusa less attractive to visitors and lead to health and safety concerns, especially those interested in swimming and water sports. Effects to recreation associated with changes in wildlife abundance are not anticipated in Region A under MO3.

No measurable changes to wildlife habitat around Hungry Horse Dam, the South Fork Flathead River or Clark Fork Rivers are expected under MO3. At Albeni Falls, water surface elevation changes may alter aquatic and terrestrial habitats, including adversely affecting forage availability for shorebirds and other waterbirds that are of interest to recreationists. Additionally, western grebe colonies would likely experience destabilization of nests and an overall decrease in reproductive success. Such changes could adversely impact wildlife viewing recreation at Albeni Falls.

**Region B – Grand Coulee and Chief Joseph Dams**

Within Region B, measures included under MO3 are focused on operational changes to the projects, and do not include structural modifications or additions. Grand Coulee would be managed to improve *Grand Coulee Maintenance Operations*, decrease *Planned Draft Rate at Grand Coulee*, and include *Lake Roosevelt Additional Water Supply* measures. In addition, Grand Coulee and Chief Joseph would be operated with slightly more flexibility for hydropower generation by relaxing restrictions on pool elevations to meet fluctuations in demand.

No construction activities would occur in Region B under MO3. Therefore, the effects to recreation in the short term would be similar to the longer-term effects described in the sections below.

***Water-Based Visitation***

Changes in water surface elevations and river flows are expected to be negligible to minor (during winter only), and would not be anticipated to affect recreational access and visitation at recreation sites at reservoirs and river reaches in Region B.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be long-term and beneficial in Region B under MO3. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, minor increases in the abundance of key anadromous recreational fishing species are anticipated in the upper Columbia River under MO3, particularly Columbia River runs of spring-run Chinook and steelhead. These improved conditions may increase opportunities for fishing for these species over the long term in Region B below Chief Joseph Dam. Reduced entrainment risk for some resident species could benefit the destination fishery at Lake Roosevelt. Changes under MO3 would also decrease stranding of kokanee and burbot eggs at Lake Roosevelt. As described in Section 3.6, *Vegetation, Wildlife, Floodplains, and Wetlands,* implementing MO3 would result in negligible changes to these resources in Region B. As such, negligible changes to the quality of recreational experience are anticipated in Region B under MO3.

**Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams**

Within Region C, measures included under MO3 are focused on both structural and operational changes to the projects. The four lower Snake River dams would be breached, which would include removing the earthen embankments to facilitate *Lower Snake Infrastructure Drawdown* measures to adjust to breached conditions. Existing equipment at the lower Snake dams would not be used for hydropower generation or navigation. Operational measures focused on the four projects would include *Drawdown Operating Procedures* and *Drawdown Contingency Plans* to facilitate drawdown and address unexpected issues. Dworshak would be operated with slightly more flexibility for hydropower generation by relaxing restrictions on ramping rate limitations (*Ramping Rates for Safety*).

The breaching of the four lower Snake River projects would have major adverse effects on current recreation in the short term in Region C. The effects are described as annual effects that would occur at three general periods of time. In the short term, construction and breaching activities would preclude all land- and water-based visitation to the lower Snake River region from construction closures, assumed to occur over a 2-year period (see Chapter 1). Post–dam breach in the short term, after breaching, some areas would reopen to land-based visitors, and the unique evolving riverine area may draw additional sightseers to the region; however, water-based recreation at the lower Snake River reservoirs would no longer occur. In the longer term, near-natural river conditions could return, which would draw visitors to the region to experience water- and land-based activities associated with the riverine environment. Although it is uncertain who would own and manage the lands in the lower Snake River, recreation facilities, infrastructure, and/or recreational access would need to be developed to facilitate river recreation visitation in the region. Long-term effects to river recreation, although uncertain, are described in this section by providing a range in potential visitation from previous studies and analysis.

***Water-Based Visitation***

Breaching the dams at the four lower Snake River projects in Region C —Lower Granite Dam, Little Goose Dam, Lower Monumental Dam, and Ice Harbor Dam—would return the lower Snake River to free-flowing conditions. This substantial change in reservoir and river conditions would affect existing developed and dispersed recreation areas and associated recreational activities. Water-based recreation activities would change from lake or flat-water activities to river-oriented recreation along the lower Snake River. Given the magnitude of these changes, the shift in usage patterns could take years to settle.

Fishing activities, as well as other recreation types, would be considerably reduced in the short term during and immediately following breach, but could rebound in the long term as anadromous fish populations improve. The largest increases in the number of Snake River salmon and steelhead are projected under MO3. Therefore, fishing for these anadromous species could increase in the long term in Region C relative to the No Action Alternative. The value for trips could also increase due to increased abundance and diversity of wild fish.

Construction and demolition activities at these projects during the breaching activities would limit access during breaching. Most of the existing facilities were developed around the reservoirs. Pre-dam river stages under dam breaching would range from approximately 8 to 100 feet below current water surface elevations. Existing water-based recreation facilities, such as boat ramps, swimming beaches, and moorage facilities, were designed to operate within very specific ranges of water elevations (generally within 5 feet of full pool). If dam breaching were to occur, none of these facilities could continue to be used without modification or relocation because river stages would be substantially lower than would be anticipated under the No Action Alternative. Some facilities, such as marinas and moorage facilities, would likely be incompatible with river conditions under MO3.

Many lower Snake River recreation areas have upland facilities such as picnic shelters, concrete walks, and interpretive signs that are located near the existing reservoirs. Although the activities that occur at these facilities are not water-dependent, the proximity of water enhances the recreation experience. Some of these facilities, such as picnic tables, could be moved closer to the river. However, other more permanent facilities such as shade structures and parking areas may not be able to be relocated because of the need to allow natural riparian functions to develop along the newly exposed river shorelines. The fish viewing facilities at the four dams would no longer be functional under the new river conditions. Fish viewing opportunities could occur at outdoor interpretive displays. Some sites would simply cease to be used because the features that attracted people would be eliminated, while other sites would be abandoned because they would be so high above or far away from the river that access would be difficult and possibly dangerous.

Dispersed recreation use would likely be reduced in the short term, but would likely return after the breaching activities and in the long term as the river and shoreline stabilize and natural features form. The action of dam breaching itself may draw some curious visitors in the short term. Many of the recreational activities that presently occur at existing dispersed sites could occur at new dispersed sites.

Lake or flatwater-oriented recreation activities, including water skiing, sailing, motorboating (in fiberglass boats), fishing for some warm-water species, and sightseeing in tour boats that cruise between Portland and Lewiston, would no longer be possible if breaching were to occur. Some activities that occur on lakes, such as fishing, swimming, hiking, camping, and wildlife viewing, could still occur. Breaching the dams would also expand opportunities in the long term for river recreation activities, such as drift boating, rafting, and kayaking that require, or are more favorable under, riverine conditions.

The four lower Snake River projects support 0.9 million annual water-based visits, 1.7 land-based visits, with a total of 2.6 million annual visits overall (i.e., including water- and land-based visits). This visitation supports $8.9 million and $24.5 million in annual consumer surplus value (social welfare), for water-based and all visitation, respectively. In the short term, major effects to social welfare would occur associated with the construction and breaching activities, with a large reduction in consumer surplus value of up to $24.5 million with major reductions in both land- and water-based visitors to the area.

After the construction and breaching activities conclude, it is possible that some of the existing land-based visitation would return, with the potential for up to 1.7 million visitors (land-based visitors pre-breach). However, the loss of water-based recreation on the lower Snake River reservoirs would result in major adverse effects in the short term post–dam breach, a decrease in consumer surplus of $8.9 million (-36%), compared to $24.5 million under the No Action Alternative.

In the long term, both water-based and land-based river recreation would become reestablished. The future physical condition of the river is uncertain, which would affect its suitability for supporting specific types of recreational activities (e.g., river rafting). In addition, it is uncertain how the environment might be managed to achieve other resource goals (e.g., fishing regulations and restrictions associated with the ESA-listed species, particularly Chinook salmon), and the effect these management decisions would have on recreation activities.

Access to the river and its recreational opportunities will be paramount for the reestablishment of river visitation to the lower Snake River. For example, parking lots, boat launches, new trailheads, access roads, etc., would need to be developed to facilitate the drawing of visitors to the region. Post–dam breach, the Corps will not have a role in providing recreation facilities. However, other Federal, state, or local government agencies, or other entities could relocate existing recreation areas or extend boat ramps (from reservoir to river) so that water-based recreation for the river reach could occur in this region. Costs to extend boat ramps in the region could range from $100,000 to $900,000 depending on the materials, length, and other factors (Corps Cost Engineering Center of Expertise; 2019). Access roads would also need to be developed. Relocating or developing a new recreation area (similar to Charbonneau and Fishhook Parks) is estimated to cost approximately $6 million.

To provide an estimate of the range of potential recreational use levels that may occur in the long term under MO3 in the lower Snake River area, this section reviews existing data and past efforts to estimate these effects. The estimates developed suggest that a wide range of potential changes to river-based recreational visitation could occur following dam breach. Information sources for this estimate include the 2002 *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement* (2002 EIS) and visitation estimates for other similar rivers in the region.

<u>2002 Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement</u>

For the 2002 EIS, a contingent behavior survey was conducted to estimate how non-fishing recreation use would change if the four lower Snake River dams were breached. Using results from this survey, visitation after dam breach was estimated to be 1.5 to 2.7 million annual recreation days after full recovery of the natural river system, excluding fishing use. Estimates of fishing visitation specifically for the lower Snake River following dam breach were not estimated (Corps 2002b, p. I3-65 to I3-66).[12] To provide an updated visitation level, the visitation was adjusted for changes in the target survey populations since the study was conducted. Based on population adjustments, the updated visitation would range from approximately 1.9 to 3.4 million (Table 3-263).[13]

The Corps had a number of concerns about the survey methods and results from the contingent behavior survey from the 2002 EIS (Corps 2002b, Section 3.2.9). In 2002, the Corps was concerned that the “potential recreation benefits associated with dam breaching may be significantly overstated” (Corps 2002b, p. I3-74), and these concerns remain. First, the result was much higher than visitation estimates for other free-flowing river/unimpounded river stretches. Second, the results suggested that visitors from California would account for over 30 percent of the visits to a near-natural lower Snake River, even though data for other free-flowing rivers/unimpounded river stretches suggested that would be unlikely. Other concerns pertained to representativeness (the target survey response rate was not met), and the associated potential for nonresponse and strategic bias.[14]

Given the Corps’ concerns, Table 3-263 also presents adjusted visitation estimates from the 2002 EIS without California visitors. Without California, visitation estimates would range from approximately 1.2 to 1.9 million, depending on whether the estimates were adjusted to current levels and the extrapolation method used. Visitation to the lower Snake River would be limited by the availability of infrastructure to access river recreational opportunities.

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[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).

**Table 3-263. Visitation Estimates for the Lower Snake River in the Long-Term, With and 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** |

Source: 2002 EIS estimates from Table 3.2-7 (Corps 2002b, p. I3-61). Estimates 1 and 2 reflect uncertainty about how to extrapolate the survey results, so two different methods were used (Corps 2002b, p. I3-61). County-level population data for 1998, the year of the contingent behavior survey, from state and county intercensal tables: 1990–2000 (Census 2016); county-level population data for 2018, most recent data available, from American FactFinder (Census 2019). Counties in each survey strata (i.e., study region) are described in the 2002 EIS (Corps 2002b, p. I3-56, I3-61).

<u>Visitation to Other Similar Rivers in the Region</u>

The 2002 EIS evaluated a number of potential additional comparison sites, including areas along the main Salmon River, middle fork of the Salmon River, and the Hells Canyon stretch of the Snake River. As stated in the 2002 EIS, "it appears that a near-natural lower Snake River would offer a very different type of recreation experience to the region's premier whitewater rivers, such as the Main Salmon River, the Middle Fork of the Salmon River, and the Hells Canyon stretch of the Snake River. In addition to whitewater, these rivers also offer a wilderness experience and spectacular scenery. In terms of accessibility, the range of activities offered, and scenery, a near-natural lower Snake River would appear to have more in common with the lower Deschutes River, the Grand Ronde River, or the lower Salmon River. It would, however, be much larger than these rivers, with about 10 times the flow of the lower Deschutes and Grand Ronde Rivers, and about 5 times the flow of the lower Salmon River. In addition, visitation data for these rivers is limited (Corps 2002b, p. 5.13-18)." The 2002 EIS concluded that "a near-natural lower Snake River would be a fairly unique recreation resource primarily because of its size, accessibility, and the available range of existing recreation facilities and activities" (Corps 2002b, p. 5.13-18).

Despite the limitations, an approach for estimating recreational visitation, primarily for fishing, to the lower Snake River after dam breaching would be to consider estimates of current visitation to other rivers in the region. The Hanford Reach of the Columbia River and the North Fork Clearwater River have been identified by Corps personnel as reasonable sites to evaluate as potentially comparable to future dam breach conditions on the lower Snake River. The Hanford Reach, which is located below Priest Rapids Dam on the Columbia River in Washington, and the North Fork Clearwater, which is located above Dworshak Reservoir in Idaho, are somewhat similar to a near-natural lower Snake River in terms of size, accessibility, and proximity to local users.

For the Hanford Reach, WDFW has estimates of fishing effort for select anadromous species (about 30,000–55,000 trips per year; NMFS 2014b; ODFW and WDFW 2018) and traffic count data for some boat launches in this reach, but no comprehensive estimates of use. The USFWS does not have visitation numbers for the Hanford Reach National Monument (Haas 2019), a significant recreation site in the reach. For the 2002 EIS, it was estimated that the Hanford Reach had 50,000 annual recreational fishing visits (Foster Wheeler Environmental and Harris 2001). Since the Hanford Reach is approximately 50 miles long, this would be equivalent to approximately 1,000 annual fishing visits per mile.

Recreational visitation data is available from BLM for sites they manage along the Clearwater River, but visitation data is not available for other sites. The partial visitation data totaled about 80,000 visits in 2018. This would be comparable to the 100,000 visits estimated for this area when the 2002 EIS was written (Foster Wheeler Environmental and Harris 2001). Since the North Fork Clearwater is approximately 135 miles long, visitation per mile would be similar to the 1,000 visits per mile for the Hanford Reach.

Estimating Visitation in the Long Term

As discussed above, the sources available for estimating recreational use levels and activities along the lower Snake River after dam breaching under MO3 suggest a wide range of estimates of potential recreational visitation that may occur post–dam breach. Applying the current estimates of visitation rates to the Hanford Reach or Clearwater River to the 140-mile lower Snake River without any other adjustments would yield an estimate of approximately 140,000 annual visits that would be anticipated in the lower Snake River in the long term. However, data for this estimate is primarily fishing-related. Given this, using estimates from these proxy sites may considerably underestimate future recreational activity on the lower Snake River.

In contrast, applying the results of the contingent behavior study conducted for the 2002 EIS would yield an estimate that would range from approximately 1.2 to 3.4 million annual visits (adjusted and unadjusted for population) under MO3 in the long term, depending on whether or not California estimates are included. As described above, the Corps has expressed concerns that the 2002 EIS may have overstated recreation benefits from dam breach.

Because the 2002 EIS specifically focused on non-fishing visitation, it would underestimate that type of recreation. Recreational fishing visitation was not included in the 2002 study due to the uncertainty around it being an allowable activity, given the current measures to regulate, protect, and support ESA-listed fish populations and habitat in the region. However, in the long term, there is the potential for recreational fishing in the lower Snake River. One approach to estimate long-term visitation post–dam breach would be to combine the proxy site estimates of 0.1 million, which primarily capture fishing visitation, with the estimates from the 2002 EIS. By doing this, long-term visitation in the lower Snake River could range from 1.3 to 3.5 million following dam breach for all types of recreational activities (water- and land-based activities). In comparison to the current water- and land-based visitation on the lower Snake River under the No Action Alternative of approximately 2.6 million, the long-term visitation estimates would suggest that visitation to the river reach (both water-based and land-based recreation) could range from 50 percent lower to 30 percent higher than under the No Action Alternative. As described above, visitation to the lower Snake River could be limited by and dependent upon visitors' ability to access the recreational opportunities.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be adverse in the short term, but beneficial in the long term. When dams are breached under MO3, reservoir conditions on the Snake River would transition from reservoir to riverine. This would have adverse effects on resident fish species that are popular with recreationists, such as walleye, that prefer reservoir conditions. Conversely, increases in the abundance of key anadromous recreational fishing species and native resident fish due to dam breach are anticipated to occur, particularly Snake River runs of spring-run Chinook and steelhead, as discussed above.

In Region C, from Lower Granite Pool to McNary Dam, dam breach would cause brief but intense periods of murky water. The level of total suspended solids is expected to reach 20,000 mg/L during the breach and remain greater than 5,000 mg/L for a month following each breach. Elevated sediment concentrations would also occur during spring runoff and other high-flow or precipitation events following breach for 2 to 7 years. When the riverbed stabilizes, the level of total suspended solids would return to less than 50 mg/L. The adverse water quality conditions combined with the changes to access and elevation discussed above would likely preclude recreational activities immediately following dam breach events and during transition to a riverine condition.

The vegetation, wetland, and wildlife analyses found that implementing MO3 would result in adverse as well as beneficial changes to wildlife-viewing opportunities in Region C during the short and long term. Immediately following dam breach, water surface elevations would drop drastically, transitioning the habitat from reservoir to riverine. There would be an expected loss of approximately 1,200 acres of woody vegetation in Region C. White-tailed deer and mule deer would be adversely impacted because suitable foraging habitat and protective cover would be destroyed. These effects would limit hunting and wildlife viewing opportunities in the short term. Waterfowl populations would decrease for several years following dam breach because of increased predation, weedy growth, and unstable shorelines, which may adversely impact wildlife recreation. Most migratory songbirds would be adversely impacted by the reduction in breeding and foraging habitats in the short term. However, some resident and migratory shorebirds would benefit from increased mudflat exposure in the short term.

According to Section 3.6, *Vegetation, Wetlands, Floodplains, and Wildlife*, historical aerial imagery of the lower Snake River indicates approximately 1,500 acres of forested and scrub-shrub habitats would develop after dam breaching. The availability and distribution of upland habitat would increase by approximately 12,500 acres following dam removal and reservoir drawdown. As forested wetlands become more established along the new riverbanks, breeding and foraging habitats would support waterfowl populations. The more contiguous woody vegetation habitat along the Snake River would improve habitat for upland mammal species such as elk, bighorn sheep, black bear, and mountain lion, which may increase in numbers over the long term. With the development of woody vegetation, increased habitat would be available for owls, cavity-nesting raptors, and fish-eating raptors over time. In the long term, the quality of the recreation experience would be improved for hunting and wildlife viewing activities from an increased abundance of wildlife. In addition, some visitors may value a river experience with more natural river features and landscapes, resulting in a relatively improved quality of the recreational experience compared to the No Action Alternative.

**Region D – McNary, John Day, The Dalles, and Bonneville Dams**

MO3 measures for Region D include operational measures and several structural measures at the four lower Columbia River projects. At all four of the projects in Region D, operations would modify the spring juvenile fish passage spill and *Reduced Summer Spill*. The four projects would be operated with more flexibility for hydropower generation by relaxing the ramping rate limitation (*Ramping Rates for Safety*). The operational measures would have similar effects in the short term and long term, as described in this section, with minimal effects to recreation resources.

Structural measures included for Region D projects include *Improved Fish Passage Turbines* at John Day; Additional Powerhouse Surface Passage at McNary; Upgrading to Adjustable Spillway Weirs at John Day and McNary; modifying Bypass Screens for Lamprey at McNary; and implementing *Turbine Strainer Lamprey Exclusion* measures at the four projects. At all four lower Columbia River projects, the *Lamprey Passage Structures* would be expanded to increase adult lamprey passage success and *Lamprey Passage Ladder Modifications* would incorporate lamprey passage features. At Bonneville, the flow control fish ladder sections would be modified to support increased adult salmon and steelhead survival.

Similar to MO1 Region D, construction of the structural measures at the four Lower Columbia River projects could have localized, short-term, adverse effects to recreation during the 2-year period when construction occurs in proximity to the recreation sites close to the dams. Effects could include disruption at project sites, noise, potential traffic congestion, and access limitations during the construction period.

***Water-Based Visitation***

Breaching the dams at the four lower Snake River projects would release substantial amounts of sediment, almost all of which would be deposited in Lake Wallula behind McNary Dam within the first 2 to 7 years. Seven recreation sites in Lake Wallula—located along the east and south sides of the Columbia River below the mouth of the Snake River—could be affected by this sedimentation permanently. These sites include Hat Rock State Park, Hood Park, McNary Yacht Club, Sacajawea State Park, Walla Walla Yacht Club, Warehouse Beach, and McNary National Wildlife Refuge. Some boat launches and beaches may be buried in sediment, which would adversely affect visitation to those areas, while other areas may experience new vegetation and wetland conditions. In order to address these effects, local entities may need to remove sediment materials, extend boat launches, and/or modify the recreation sites to adapt to sediment and potentially new vegetation and wetland conditions, depending on the localized effects and desired recreation conditions.

The seven affected sites in Lake Wallula support 163,000 water-based visits during a typical year (5.6 percent of total Region D visitation), which support $1.5 million in annual consumer surplus value (social welfare). This social welfare may be considerably reduced immediately after breaching of the dams and last for up to several years until any issues associated with the sediment and recreational access are addressed. Some types of visitation may increase, and some visitors may experience increased fishing success if the abundance of key recreational species (Snake River runs of spring-run Chinook and steelhead) increases in Region D. Further, after the breaching, visitors may adapt to the conditions by visiting recreation areas downstream or in other places not directly impacted by the sedimentation.

Changes in water surface elevations and river flows are expected to be sufficiently minor as not to affect recreational access and visitation at the other three reservoirs and river reaches in Region D under MO3.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be adverse in the short-term, but beneficial in the long term. Short-term effects of dam breach on the quality of water-based recreational experience in Region D would be largely adverse for fishing, hunting, and wildlife viewing opportunities. In addition to access issues discussed above, increased sedimentation, particularly in the Lake Wallula area, would adversely affect water quality and would adversely affect wildlife and associated wildlife viewing opportunities. In general, water quality throughout the Columbia River would be poor in the several years following dam breach which would decrease foraging opportunities, limit reproductive success for piscivorous birds, and compromise wildlife viewing opportunities overall.

As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, and above for Region C, long-term increases in the abundance of key anadromous recreational fishing species are anticipated to occur due to dam breach under MO3. To the extent that increases in abundance occur, this would increase opportunities for anadromous recreational fishing throughout the region on the Columbia River. With the potential for increased abundance of anadromous fish, recreational wildlife watching activities could benefit if the wildlife prey on salmon and other anadromous fish.

Increased sediment deposition in Lake Wallula under MO3 would support the development of wetland habitats in the lower Snake River over the longer term. Wetlands surrounding Lake Umatilla are expected to experience increases in the breeding of amphibians, reptiles, mammals, and birds, which may benefit wildlife watching and duck hunting activities over the long term.

**REGIONAL ECONOMIC EFFECTS**

Short-term adverse effects of dam breach on current reservoir recreation facilities and visitation would be major, with water levels falling substantially below No Action Alternative conditions and limitations for recreational access during the breach and construction period. A wide range of businesses that serve visitors would be adversely affected in the short term when recreationists forego trips to the region. Some facilities, such as marinas and moorage facilities, that serve water-based visitors would likely be incompatible with river conditions under MO3, and employment at these businesses would likely be eliminated.

In the short term during construction activities, a decrease of 2.3 million water- and land-based visitors in Region C could result in decreased visitor spending of $103 million, a decrease of 83 percent compared to non-local visitor spending under the No Action Alternative. Reduced visitor spending would result in a decrease of approximately 1,230 jobs, $39 million in labor income, and $147 million in sales during this construction period.

After the construction and breaching period is over, access would be reopened to some of the recreation areas, and it is likely that a portion of the land-based visitors, such as sightseers, hikers, and others, would visit the region after construction while the reservoirs transition to river conditions. A reduction in only the water-based visitors at the reservoirs (land-based visitation would remain), compared to No Action Alternative, would result in a decrease of 820,000 non-local visitors and $37.4 million in visitor spending in the region. The decreased non-local water-based visitor spending would lead to decreases in 450 jobs and $14 million in labor income and $53 million in sales compared to the No Action Alternative.

Although the specific response of visitors to new river conditions is uncertain, the establishment of near-natural river conditions would result in changes to regional economic effects over time. In particular, new opportunities for land- and water-based river recreation and possibly anadromous recreational fishing may offset visitation losses in Region C associated with reservoir or flatwater-oriented recreation activities, and recreational opportunities may even increase in the long term relative to the No Action Alternative. Again, river recreation in the long-term would be dependent on the development of recreational facilities and infrastructure to facilitate access. Tourism businesses, such as retail, rental businesses, and service providers, would likely have to adapt to the new type of visitor who may demand different types of activities, services, gear, and retail merchandise.

> "In particular, new opportunities for anadromous recreational fishing opportunities or other river-based recreation may replace those lost in Region C for lake or flatwater-oriented recreation activities (e.g., water skiing, sailing, fishing for some warm-water species) and may even increase in the long term."

Reduced water quality due to increased sedimentation in Region D at water-based recreation sites in Lake Wallula may render sections of this area unusable to recreationists for a period of time following dam breach (approximately 2 to 7 years). Non-local visitor expenditures associated with water-based visitation at affected sites could decrease by up to $6.1 million under MO3. The specific site conditions may not preclude visitation entirely, which would render this estimate higher than would be likely. However, were it to occur, this change would represent a decrease of 2.6 percent of non-local visitor expenditures on recreation in Region D relative to the No Action Alternative. Regional economic effects of this change in regional expenditures, should they occur, would be a reduction of 80 jobs, $3 million in labor income, and $10 million in sales when compared to the No Action Alternative. Effects would likely be most acute in the short term. Over time, Lake Wallula visitation would likely rebound to levels similar to the No Action Alternative and could increase if visitation from the lower Snake River is diverted to this area.

As a result of changes in boat ramp accessibility, recreational expenditures associated with visitation at Lake Koocanusa and Hungry Horse in Region A would decrease annually by $15,000 under MO3. The economic effects of this change in regional expenditures would be negligible. No changes to visitation or expenditures are anticipated in Region B under MO3 relative to the No Action Alternative.

As noted above in the social welfare analysis, potential long-term increases in anadromous fish populations could increase anadromous recreational fishing activities would likely occur in Regions C and D, drawing additional visitors. Expenditures associated with these increases in recreational fishing could also accrue.

**OTHER SOCIAL EFFECTS**

The changes in visitation, particularly along the lower Snake River in Region C and in Lake Wallula in Region D, could produce substantial beneficial changes to other social effects relative to the No Action Alternative in the long term, despite adverse changes in the short term. Communities that are heavily reliant economically on visitation to affected sites would be adversely impacted in the short term. The identity of the local economies would be changed immediately after the breaching of the dams and for several years depending on when, and the extent to which, river recreation activities and visitation are established (and access is developed) on the lower Snake River. People who currently visit the four lower Snake River projects and sites along the east and south sides of Lake Wallula would be affected. To the extent that visitors are not able to easily access alternative recreation sites that provide similar benefits to sites that would be unavailable under this alternative, physical, mental, and social health benefits of individuals and their communities from recreation in Region C could be diminished, particularly in the short term.

However, restoration of riverine conditions and increases in anadromous fish species to the lower 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. Natural landscapes and the transition to a natural river state would likely provide many people some social benefits, as well as educational and scientific research opportunities associated with this unique area. These benefits would accrue in Regions C and D.

Adverse effects to resident fish species in the short term would have adverse effects on fishing experiences in Region C under this alternative, which, in turn, would have adverse effects on the well-being of those recreationists who value affected fish, particularly tribes.

**SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 3**

Adverse effects of MO3 on recreational visitation at the four lower Snake River projects in Region C are anticipated to be major due to dam breach and construction activities. Some land-based visitation would return to the region following the construction activities once areas are opened to recreation. With about one-third of the current visitation associated with water-based activities, the loss of this visitation would be large and adverse. However, as the river returns to natural conditions, river-based recreation would increase over time, given that recreational access and infrastructure is developed; the exact long-term beneficial impacts to visitation and social welfare are uncertain, although the losses in reservoir recreation would be offset by increases in river recreation visitors, and may eventually increase to levels and values greater than under the No Action Alternative. For a comparison of anticipated social welfare and regional economic effects across alternatives refer to Table 41 in Appendix M.

Water quality effects are expected to be major at Lake Wallula in Region D in the short term due to temporary sedimentation effects associated with dam breach; water-based visitation would be adversely affected.

An increased quantity and quality of recreational fishing trips for key anadromous species, namely Snake River runs of salmon and steelhead, could occur. However, while Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, describes increased abundance of these species under MO3, other factors may limit their long-term success (e.g., ceased hatchery operations on the lower Snake River).

Table 3-264 presents a summary of MO3 effects, including the anticipated changes in average annual recreational visitation, social welfare, and economic effects by region and in total relative to the No Action Alternative. Across the Basin in the short term, total recreational visitation and associated social welfare effects could decrease by up to 21 percent in the study area (approximately 2.7 million visits and $26.0 million across all locations).

Expenditures associated with 2.4 million non-local recreational visits could decrease by up to $109 million across the Basin in the short term during the breaching and construction activities (representing 22 percent of non-local visitor expenditures on recreation across the Basin under the No Action Alternative). The decrease of 2.4 million non-local visitors would result in decreases of 1,420 jobs, $59 million in labor income, and $189 million in sales. The largest effects would be anticipated at the four lower Snake River projects in Region C and Lake Wallula in Region D due to dam breach and associated sedimentation effects.

Changes in other social effects could be substantial, as communities that are economically dependent on visitation to these five projects could be adversely affected, particularly in the short term. Users of these projects could experience diminished physical, mental, and social health benefits associated with the reduced quantity or quality of recreational activities (staying home or diverting recreational use to less-preferred sites), particularly in the short term. The effects to social welfare, regional economic, and other social effects could be moderated, at least to some extent, through adaptation of recreationists to new conditions over time (e.g., recreationists converting to river-oriented recreation). Restoration of riverine conditions and increases in anadromous fish species to the lower 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.

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 Koocanusa 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.<br>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).<br>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. |

| Region | Social Welfare Effects (2019 dollars) | Regional Economic Effects (2019 dollars) | Other Social Effects |
|---|---|---|---|
| | 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.<br>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.<br>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.<br>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). | 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. | 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.<br>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.<br>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.<br>Recreationists whose recreational activities depend on reservoir conditions could experience reduced well-being associated with the reduced availability of reservoir recreation within Region C. |

| 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.<br>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.<br>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.<br>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.<br>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. |

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### *3.11.3.6 Multiple Objective Alternative 4*

The additional combination of fish measures that differ from the other MOs include *Spillway Weir Notch Inserts*, changes to the juvenile fish transportation operations (*Spring & Fall Transport* and *No Summer Transport* measures), *Spill up to 125% TDG*, the highest spill target range considered in this EIS. Other measures include annual *Drawdown to MOP* at the lower Snake River and Columbia River reservoirs, a measure for establishment of riparian vegetation, dry year augmentation of spring flow with water stored in upper basin reservoirs, and Additional Powerhouse Surface Passage for kelt and overshoots.

There are anticipated changes in water surface elevations at Lake Koocanusa and Hungry Horse Reservoir and Lake Roosevelt during a typical water year. Lake Roosevelt could experience a longer period of time with reduced boat ramp accessibility, especially during low-water years. Recreational access is managed by NPS, Confederated Tribes of the Colville Reservation, and the Spokane Tribe of Indians, therefore the tribal communities around Lake Roosevelt could be affected by these changes. In addition, during low-water years, there may be accessibility impacts at Lake Pend Oreille boat ramps, fixed docks, pedestrian ramps at launches, commercial marinas, community marinas, boat-up restaurants, and fueling and private docks that need the stable summer elevation of 2,062 feet to function. Water quality and fishing conditions within reservoirs, as well as in some stream reaches below reservoirs, may also be affected under MO4. The effects of MO4 on recreation are described in more detail for each region in the sections below.

**SOCIAL WELFARE EFFECTS**

The focus of effects on water-based visitation in this section are described as annual effects that would occur after implementation of MO4. Over time, visitors may adjust their behavior to adapt to changes in accessibility and site quality, such as using different sites in the CRS. These long-term adaptations could reduce effects on visitation.

**Region A – Libby, Hungry Horse, and Albeni Falls Dams**

Measures included for MO4 for projects within Region A include operational changes only and are very similar to the operational measures proposed under MO1. These similar measures include actions like *Modified Draft at Libby*, juvenile fish operations (*Spring & Fall Transport* and *No Summer Transport*), water management flexibility, and other operations. In addition, MO4 includes limiting *Winter Stage for Riparian* at Bonners Ferry. Similar to MO1, because no structural measures are planned under MO4, the effect on recreation is directly tied to changes in water elevations and flows related to operational changes. These changes would be similar in the short term and longer term, over the 50-year period of analysis.

***Water-Based Recreational Visitation***

Anticipated changes in water surface elevations under MO4 would affect boat ramp accessibility relative to the No Action Alternative at Lake Koocanusa (Libby Dam) and Hungry Horse Reservoir in Region A for some periods of time in a typical year. This change in accessibility would likely affect visitation to these sites. Changes in water levels at other reservoirs in the region would not affect accessibility and visitation in a typical year. Note, dry year conditions are different from typical years and are discussed below. Due to changes in project outflows, recreational activities occurring in river reaches downstream of Libby Dam and Hungry Horse Dam could cause beneficial or adverse localized effects, or both, depending upon the river-based recreation activity.

At Lake Koocanusa, median water surface elevations would decrease most of the year under MO4 relative to the No Action Alternative, but would increase in January, February, May, and June. These changes would reduce boat ramp accessibility relative to the No Action Alternative in March and April, and increase accessibility in June and December (little visitation occurs during December, however). Due to changes in boat ramp accessibility (both decreases and increases), water-based recreational visitation is estimated to decrease by less than 0.1 percent (approximately 21 visits) annually under MO4 relative to the No Action Alternative at Lake Koocanusa in a typical water year. In a high-water year (i.e., 25th percentile) water-based visitation would increase slightly (0.1 percent) relative to the No Action Alternative high-water year. In a low-water year (i.e., 75th percentile), water-based visitation would also increase slightly (0.8 percent) relative to the No Action Alternative low-water year. In these years, the increased water levels in June are anticipated to lead to increases in visitation that are larger than anticipated decreases.

At Hungry Horse Reservoir, median water surface elevations would be lower across all months under MO4 relative to the No Action Alternative, with the biggest decreases of 7 to 9 feet between October and January. The lower water surface elevations would result in decreased boat ramp accessibility in every month except July, August, and September. Because recreational visitation typically occurs between May and September at Hungry Horse, changes in boat ramp accessibility would lead to changes in water-based visitation in May and June only.

Water-based recreational visitation at Hungry Horse is expected to decrease by 1.4 percent (31 visits) annually in a typical year. In low- and high-water years, visitation at Hungry Horse would decrease by less than 1 percent and about 2.5 percent, respectively. Changes in social welfare are anticipated to be about $500 across Lake Koocanusa and Hungry Horse Reservoir in a typical year. Negligible to minor effects on recreational visitation would be expected.

In low-water years, water surface elevations at Lake Pend Oreille (Albeni Falls) would be 1 to 3 feet lower between July and September under MO4 relative to the No Action Alternative. While the analysis does not detect changes in boat ramp accessibility from these changes in water levels at Federal- and state-managed boat ramps, major adverse effects to recreation associated with impaired lake aesthetics (e.g., exposed mud flats) and reduced functionality of fixed docks and other infrastructure are possible under MO4 in low-water years (i.e., low-water measured at 75th percentile). There are over 2,000 fixed docks, city- and county-managed boat ramps, and other infrastructure in Lake Pend Oreille that are sensitive to changing lake levels. The Lake Pend Oreille area is an important regional tourist destination in Region A, supporting as many as one million visits annually.[15] A substantial proportion of this visitation occurs in summer months and is water-based. According to Bonner County Assessor's Office, there are approximately 3,100 waterfront property owners on Lake Pend Oreille and Pend Oreille River, many of whom are seasonal visitors (Lake Pend Oreille, Pend Oreille River, Priest Lake and Priest River Commission [Lakes Commission] 2019). The Lakes Commission reports that accessibility impacts can occur from just a 1-foot drop in lake elevation. For example, the Lakes Commission reports that at least 80 percent of lakefront homes have fixed infrastructure that makes mooring a boat difficult and unsafe in low-water conditions. There are also 20 marinas on the lake (Lakes Commission 2019). The Lakes Commission provided cost information for various infrastructure modifications that would be needed to accommodate lower water levels at Lake Pend Oreille. Using this information, the cost of extending fixed and floating docks to accommodate lower water levels was estimated to be approximately $4,500 per fixed dock and $1,575 per floating dock (both inclusive of a 50 percent contingency). Given this, costs to extend fixed docks could exceed $9 million (Lakes Commission 2019). There would be additional costs for modifying other types of infrastructure including pedestrian ramps at launches, commercial marinas, community marinas, boat-up restaurants, and fueling docks.

Given this, a 1- to 3-foot decline in water surface elevations has the potential to have major adverse effects on recreational visitation in low water level years. These effects would reduce the social welfare benefits associated with recreational visitation at Lake Pend Oreille.

In addition to changes in reservoir elevations, river flows and stages in the region would change relative to the No Action Alternative. Increased occurrence of higher flows may create localized water turbidity and adversely affect nearby in-river recreational fishing activities. However, rafting and paddling activities may be positively affected. Both positive and adverse effects under MO4 are anticipated to be minor in river areas. The largest changes in monthly median outflows from Libby Dam during peak recreation season would be a decrease of 17 percent in May relative to the No Action Alternative and an increase of 23 percent in July. At Bonners Ferry, further down the Kootenai River, flows and stages change most in winter months when visitation is low. Along the Flathead River at Hungry Horse Dam and Columbia Falls, the biggest changes in monthly median outflow during peak recreation season occur in July to September, when Hungry Horse outflows would increase by up to 37 percent, and flows on the Flathead River at Columbia Falls would increase by about 20 percent. Smaller changes in river flows and stages (less than 10 percent) would occur in other parts of Region A during peak recreation season under MO4.

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[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).

#### *Quality of Recreational Experience*

Changes in the quality of recreational experience are anticipated to be adverse in Region A under MO4. Similar to MO2, reservoir drawdowns and increased flushing rates could reduce overall food availability and habitat for resident fish species, which could adversely affect fishing conditions at Hungry Horse and, to a lesser extent, Lake Pend Oreille and the Kootenai River. Specifically, as described in Section 3.5, Aquatic Habitat, Aquatic Invertebrates, and Fish, bull trout and Westslope cutthroat trout could have increased entrainment risk and some reduced habitat and food availability under MO4 in Region A compared with the No Action Alternative. This could have adverse effects on recreational fishing experiences under MO4 in Region A relative to the No Action Alternative. Implementation of MO4 at Hungry Horse Dam may lead to an increased exposure of wildlife to predation when the reservoir is drawn down, which may impact recreational hunting and viewing of wildlife species. In addition, near-shore areas used for recreation (such as swimming and non-motorized boating) and river tributaries may be more difficult to access due to lower lake levels, as well as greater aquatic plant growth.

### Region B – Grand Coulee and Chief Joseph Dams

Similar to Region A, MO4 measures for Region B are focused on operational changes at the projects and do not include structural measures. Grand Coulee operational measures include various flood risk management operations such as Updating System FRM Calculations, developing *Winter System FRM Space*, and decreasing *Planned Draft Rate at Grand Coulee*. Chief Joseph operational measures include increased diversions for water supply. In addition, a Grand Coulee operations measures would be added under MO4 to meet the *McNary Flow Target* by adding additional augmenting flows in the lower Columbia River (in addition to those that occur under No Action) during juvenile salmon outmigration period in low water years.

#### *Water-based Recreational Visitation*

Anticipated changes in water surface elevations under MO4 would affect boat ramp accessibility at Lake Roosevelt in Region B relative to the No Action Alternative. Other reservoirs in the region would not be affected. Relative to the No Action Alternative, anticipated water surface elevations would be lower across all months. Lake Roosevelt spans from RM 596 to about RM 748; between RM 616 and 720 (three of the four H&H index locations where elevations were estimated), the biggest anticipated decreases in median monthly water levels would be 8 feet in January and June, 7 feet in February, 6 feet in December, and 5 feet in May. Smaller changes of 2 to 3 feet would occur in March, July, August, September, and November. Anticipated decreases follow a similar pattern at the other index location where elevations were estimated (RM 740), but are generally smaller.

These lower water surface elevations would reduce boat ramp accessibility at 16 of the 22 analyzed boat ramps at Lake Roosevelt. Of these 16 affected boat ramps, 11 would lose 7 to 19 days of accessibility. The remaining 5 boat ramps—Evans, Hawk Creek, Marcus Island, Napoleon Bridge, and North Gorge—are anticipated to lose 55 to 63 days of accessibility annually in a typical water level year. The minimum usable elevations for these 5 boat ramps (1,280 or 1,281 feet) are the highest elevations of all boat ramps in the lake. Some other boat ramps are accessible to as low as 1,222 feet NGVD29. Evans Creek is located near River Mile 635, while the others are located between River Miles 711 and 722. Thus, most of the effects are anticipated in the northern part of the reservoir.

The changes under MO4 would result in decreases in boat ramp accessibility of 15 to 18 percent in January, February, and May; 11 percent in June; and 7 percent or less in other months at Lake Roosevelt. Overall, average annual water-based visitation is expected to decrease by 6 percent or approximately 45,000 visits at Lake Roosevelt in typical years. Seventy percent of lost visits occur in May, June, and August, with 28 percent of the total decrease occurring in June. Smaller losses occur in the other months. In a high-water year (i.e., 25th percentile) water-based visitation would decrease by over 6 percent (i.e., similar to a typical year) while in the low-water year (i.e., 75th percent) water-based visitation would decrease by over 24 percent (a major adverse effect), or about 175,000 visits. The low-water year result is due to the *McNary Flow Target* measure. Decreased visitation under MO4 in a typical water year would result in an average annual decrease of $684,000 in social welfare. In a low-water year, there would be an average annual decrease of $2.6 million in social welfare.

Recreational access is managed by NPS, Confederated Tribes of the Colville Reservation, and the Spokane Tribe of Indians.

In addition to the effects quantified above for water-based recreation, lower water surface elevations may affect non-water activities through changes in aesthetics and the landscape (e.g., increased size of sandy beach areas), as well as other factors. These additional effects to water-based recreation may not be captured in the analysis above (e.g., lower fishing success due to lower water surface elevations).

In addition to changes in reservoir elevations, river flows and stages in the region would change relative to the No Action Alternative. Monthly median outflows from Grand Coulee, Chief Joseph, Wells, Rocky Reach, Rock Island, Wanapum and Priest Rapid Dams are expected to decrease by up to 11 percent in September relative to the No Action Alternative. These changes in flows may affect recreation near the dams, but likely not in the broader reservoirs. Smaller changes in river flows and stages (less than 10 percent) are anticipated elsewhere or at other times of year in Region B.

***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be adverse as well as beneficial in Region B under MO4. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, slight long-term improvements in Chinook salmon and steelhead metrics, including instream fish survival, are anticipated as compared to the No Action Alternative under MO4 in Region B, though these improvements would be less than those anticipated under MO3. These benefits may be noticeable to recreational anglers. Conversely, there would also be increased entrainment risk for some resident species that could adversely affect the destination fishery at Lake Roosevelt. Increased stranding is also anticipated for kokanee and burbot eggs in Lake Roosevelt.

Lake Roosevelt may experience increased shoreline erosion, which could increase total suspended solids in the water and reduce water clarity. This could adversely affect recreation on the reservoir. Changes in water surface elevations downstream of Chief Joseph are not expected to result in measurable effects on wildlife habitat or populations in the Chief Joseph area. Some changes could reduce pool elevations in Lake Roosevelt upstream of Grand Coulee Dam, affecting wetland habitats, but these generally are expected to have negligible effects on recreationists.

**Region C – Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor Dams**

MO4 measures for Region C again are similar to MO1 measures for Region C but also include some additional structural and operational measures. The operational measures are focused on making improvements and providing flexibility across authorized project purposes while the structural measures are focused on improving passage conditions for ESA-listed salmonids and Pacific lamprey.

Similar to MO1, the operation measures include added operating range flexibility at the lower Snake River for added hydropower generation, and modified timing of the lower Snake Basin draft for additional cooler water. In addition, MO4 targets *Spill to 125% TDG* and includes annual *Drawdown to MOP* measures at the Lower Snake River and Columbia River reservoirs. The structural measures included for projects within Region C include Additional Powerhouse Surface Passage at Ice Harbor; *Spillway Weir Notch Inserts* at Lower Granite, Lower Monumental, and Ice Harbor projects; Lower Granite Trap Modifications; adding *Lower Snake Ladder Pumps* to provide cooler water for adult fish ladders at Lower Monumental and Ice Harbor Dams; and installing entrance weir caps at the four Lower Snake River Projects. In addition, *Spillway Weir Notch Inserts* would be added to help facilitate downstream passage of adult salmon.

As described previously, the operational measures would have similar effects to water elevations and flows over the period of analysis. The structural measures could have localized, short-term effects to recreation during the anticipated 2-year period when construction occurs in proximity to the recreation sites close to dams. Effects could include disruption at project sites, noise, potential traffic congestion, and access limitations during the construction period.

***Water-Based Recreational Visitation***

Changes in water surface elevations and river flows are expected to be sufficiently minor as not to affect recreational access and visitation at recreation sites at the five reservoirs and river reaches in Region C.

#### ***Quality of Recreational Experience***

Changes in the quality of recreational experience are anticipated to be adverse as well as beneficial in Region C under MO4. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, instream survival and adult returns of modeled anadromous fish species would increase slightly under MO4 compared to the No Action Alternative. Increases in median abundance of Snake River spring-run Chinook would occur in the Middle and South Forks of the Salmon River (tributaries to the Snake River upstream from Lewiston). Minor to moderate increases in median abundance of Snake River spring-run Chinook and steelhead would occur from Lower Granite Dam to the mouth of the Snake River. These benefits may be noticeable to recreational anglers. However, there may also be increased gas bubble trauma for bull trout and other resident fish in Region C. Water quality changes that could affect recreation conditions are expected to be negligible under MO4 in Region C.

In Region C, operational measures under MO4 would result in changing habitat conditions in some areas along the Snake River that would experience more frequent inundation. Slight increases in wetland habitat in some locations may have a minor benefit to recreational activities that are dependent on wetland species, such as wildlife viewing and hunting. No changes would affect wildlife habitats or populations along the Clearwater River upstream of the confluence with the Snake River. As such, no effects to recreation are anticipated along the Clearwater River upstream of the confluence with the Snake River in Region C under MO4.

### Region D – McNary, John Day, The Dalles, and Bonneville Dams

Similar to Region C, MO4 measures planned for Region D include operational measure and several structural measures. Structural measures included for Region D projects include installing *Improved Fish Passage Turbines* at John Day and constructing a surface passage route for fish through McNary. In addition, similar to Region C (lower Snake River projects), *Spillway Weir Notch Inserts* would be added to help facilitate downstream passage of adult salmon. The operational measures include operating range flexibility at the John Day project, increasing *Spill to 125% TDG*, annual *Drawdown to MOP* at the lower Snake River and Columbia River reservoirs, and Additional Powerhouse Surface Passage.

Similar to other regions, structural measures included for Region D projects could have localized, short-term effects to recreation during the anticipated 2-year period when construction occurs in proximity to the recreation sites close to dams. Effects could include disruption at project sites, noise, potential traffic congestion, and access limitations during the construction period. The operational measures would have similar effects to water elevations and flows over the 50-year period of analysis.

#### ***Water-Based Recreational Visitation***

Changes in water surface elevations and river flows are expected to be sufficiently minor as not to affect recreational access and visitation at recreation sites at the four reservoirs and river reaches in Region D.

#### *Quality of Recreational Experience*

Changes in the quality of recreational experience are anticipated to be adverse as well as beneficial in Region D under MO4. As described in Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*, slight improvements in Chinook salmon and steelhead metrics, including instream fish survival, under MO4 are anticipated as compared to the No Action Alternative in Region D, though these improvements would be less than anticipated under MO3. Minor increases in median abundance of Snake River spring-run Chinook and steelhead are anticipated from Bonneville Dam to the mouth of the Snake River. Minor changes in median abundance of upper Columbia River spring-run Chinook (increase) and steelhead (decrease) are also anticipated from the mouth of Bonneville Dam to the mouth of the Snake River. However, drawdown to MOP could reduce sturgeon habitat. It is uncertain whether these benefits would noticeable to recreational anglers.

Changes in drawdown operations between McNary and John Day Dams could slightly increase turbidity and phytoplankton, decreasing water clarity and potentially affecting recreational activities in Region D under MO4. Changes to water quality conditions that could affect recreation are not expected at other sites in the region.

The vegetation, wetland, and wildlife analyses found that patterns of inundation, seasonal drying, accretion, and erosion, and effects from these processes on wildlife habitat in the Columbia River estuary would not substantively change from the No Action Alternative.

### REGIONAL ECONOMIC EFFECTS

As a result of changes in boat ramp accessibility in a typical year, recreational expenditures associated with non-local visitation at Lake Koocanusa and Hungry Horse in Region A would decrease annually by $2,300 under MO4. Recreational expenditures associated with non-local visitation at Lake Roosevelt in Region B would decrease annually by $1.8 million under MO4 in a typical water year. These changes represent less than 1 percent of non-local recreational expenditures in the Basin under the No Action Alternative. Because most changes in visitation would occur along the northern portion of Lake Roosevelt, communities reliant on recreation in that area—including Northport, Kettle Falls, and Colville—could be adversely affected. No changes to visitation are anticipated in Region C or D under MO4 relative to the No Action Alternative.

Overall, the change in non-local visitor regional expenditures in a typical year would result in approximately 22 fewer jobs, $780,000 less in labor income, and $2.2 million less in sales. Most of the effects would be in Region B, where about 89 percent of affected visitation is non-local. In a low-water year, decreased expenditures associated with non-local visitation in Region B (Lake Roosevelt) would lead to 74 fewer jobs, $2.2 million less in labor income, and $6.9 million less sales, a major adverse effect.

As discussed above, the analysis does not detect changes in boat ramp accessibility at Federal- and state-managed boat ramps at Lake Pend Oreille. However, during low-water years under

MO4 between July and September major adverse impacts to recreation associated with impaired lake aesthetics (e.g., exposed mud flats) and reduced functionality of fixed docks and other infrastructure could occur. Because the Lake Pend Oreille area is an important tourism destination, reductions in visitation would affect the local economy, including the potential to adversely affect a wide range of businesses that serve visitors.

**OTHER SOCIAL EFFECTS**

There would be beneficial and adverse social effects under MO4. Recreation would continue to provide other social effects associated with considerable recreational opportunities in the region under MO4. Continued operation of the system would provide benefits to community well-being, cohesion, and identity associated with recreational activities. In a typical water year, changes to recreational visitation due to boat ramp access changes would be minor and adverse in most locations under MO4, although Lake Roosevelt would experience a 6 percent decrease in water-based recreation (a moderate effect). In low-water years, Lake Pend Oreille (Region A) and Lake Roosevelt (Region B) could experience major adverse effects to visitation, social welfare, and regional economic effects. Communities that are heavily reliant economically on visitation to affected sites during these low-water periods would be adversely impacted in the short term. If recreational access is not available at Lake Roosevelt and Lake Pend Oreille during low-water years and to the extent that visitors are not able to easily access alternative recreation sites that provide similar benefits, physical, mental, and social health benefits of individuals and their communities could be diminished, particularly in the short term.

Anadromous fish species populations would improve under this alternative, which would benefit recreational experiences in Regions C and D. Restoration of riverine conditions and increases in anadromous fish species to the lower Snake River has been a long-term objective of area tribes, who would experience benefits to their ability to utilize the area recreationally and exercise treaty rights, in addition to other cultural and spiritual benefits. Natural landscapes and the transition to a natural river state would likely provide many people some social benefits, as well as educational and scientific research opportunities associated with this unique area. These benefits would accrue in Regions B, C, and D.

Adverse effects to resident fish species would have adverse effects on fishing experiences in Region A under MO4, which, in turn, would have adverse effects on the well-being of those recreationists who value affected fish, particularly area tribes.

**SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 4**

Overall, MO4 is anticipated to result in minor to moderate adverse effects in a typical water year, as well as beneficial effects on recreational visitation over the long term. Moderate adverse effects could occur at Lake Roosevelt during typical water years, while localized major adverse effects could occur during low-water years from the *McNary Flow Target* measure. During low-water years, water-based visitation could decrease at Lake Pend Oreille in Region A due to adverse impacts to lake aesthetics (e.g., exposed mud flats) and reduced functionality of fixed docks, some city- and county-owned boat ramps, and other infrastructure. Major adverse impacts to visitation could occur, resulting in decreased social welfare and regional economic activity during low-water years.

Table 3-265 presents a summary of MO4 effects, including the anticipated changes in average annual recreational visitation, social welfare, and regional economic effects by region and in total relative to the No Action Alternative. Across the Basin, total recreational visitation is anticipated to decrease annually by 0.4 percent (46,000 visits) and associated social welfare effects by $0.7 million associated with reductions in access to boat ramps in a typical year. The change in non-local visitor regional expenditures in a typical year would result in approximately 22 fewer jobs, $780,000 less in labor income, and $2.2 million less in sales. In low-water years, decreased expenditures associated with non-local visitation in Region B would lead to 74 fewer jobs, $2.2 million less in labor income, and $6.9 million less in sales. The largest adverse effects are anticipated at Lake Roosevelt in Region B in a low-water year and at Lake Pend Oreille in Region A in a low-water year. Some increased shoreline erosion may also occur in Region B. For a comparison of anticipated social welfare and regional economic effects across alternatives refer to Table 41 in Appendix M.

Resident fish entrainment would increase in Region A, which could adversely affect the quality of fishing experiences there. However, anadromous fish species would benefit under this alternative, which could benefit recreationists in Regions B, C, and D. There would be negligible to minor adverse effects to the quality of hunting, wildlife viewing, swimming, and water sports at river recreation sites in the region under MO4.

During low water level years under MO4, water-based visitation may decrease at Lake Pend Oreille in Region A due to reduced functionality of fixed docks and reduced usability of city- and county-owned boat ramps, marinas, and municipal facilities. Over time, visitors may adjust their behavior to adapt to changes in accessibility and site quality, such as using different sites on the system. These long-term adaptations could reduce effects of changes in visitation. At Lake Pend Oreille during low-water years, active management, such as boat dock extensions and possibly dredging would likely be needed to reduce the effects of low water.

**Table 3-265. Changes in Economic Effects of Recreation Under Multiple Objective Alternative 4 Relative to the No Action Alternative**

| Region | Social Welfare Effects | Regional Economic Effects (2019 dollars) | Other Social Effects |
|---|---|---|---|
| Region A | A reduction of less than 100 water-based recreational visits (0.1 percent of regional water-based visitation) would occur at Lake Koocanusa 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.<br>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. | 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. | During low-water years only, social effects could occur to residents and communities at Lake Pend Oreille from decreased visitation and tourism activity.<br>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. |

| 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.<br>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.<br>Likewise decreased well-being of water-based recreation visitors could occur due to the sizable reduction in recreation days during a low-water year.<br>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.<br>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.<br>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. |

| Region | Social Welfare Effects | Regional Economic Effects (2019 dollars) | Other Social Effects |
|---|---|---|---|
| Total | 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.<br>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. | 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.<br>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.<br>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 and Lake Pend Oreille from decreased visitation and tourism activity during low water years.<br>Generally, improvements in anadromous fish populations would contribute to improved well-being for recreationists in Regions C and D. Some adverse effects associated with decreases in resident fish populations in Region A. |

#### ***3.11.3.7 Tribal Interests***

The presence of dams and system operations have had long-term adverse effects on the recreational opportunities for area tribes, particularly for fishing and hunting. Section 3.16, *Cultural Resources*, and Section 3.17, *Indian Trust Assets, Tribal Perspectives, and Tribal Interests*, provide additional information about ongoing effects as well unique effects of MOs on tribal recreational activities, subsistence activities, and cultural practices.

The fish resources of the Columbia River Basin are caught in commercial, recreational, and tribal ceremonial and subsistence fisheries both within the Basin and in the ocean off the coasts of Washington, Oregon, California, British Columbia, and Alaska. Fish are a natural resource of invaluable importance to the tribes of the region, and some tribes reserved the right to catch these fish in treaties signed with the United States. The Federal government has a trust responsibility to preserve the treaty-reserved rights of those tribes. The Fisheries and Passive Use section of this EIS (Section 3.15) discusses ceremonial and subsistence fishing activities, as well as commercial fishing activities in more detail.

At Lake Roosevelt, the Spokane Tribe of Indians and the Confederated Tribes of the Colville Reservation manage recreation in those parts of the Lake Roosevelt National Recreation Area that fall within their respective reservation boundaries. This tribal management of recreation is one of the outcomes of the Lake Roosevelt Cooperative Management Agreement of 1990. Other tribes also manage recreation areas, provide tours, and other services that are dependent on natural conditions and resources in the Basin.

Adverse effects to resident fish species would have adverse effects on fishing experiences in Region A under MO4, which, in turn, would have adverse effects on the well-being of those recreationists who value affected fish, particularly area tribes.

Anadromous fish species populations would improve under MO1, MO3, and MO4 in the lower Snake River, which has been a long-term objective of area tribes. Under these MOs tribes that use that area would experience benefits in their ability to recreate and exercise treaty rights, as well as experience other cultural and spiritual benefits. The largest benefits to these fish would accrue under MO3 and MO4. However, tribes in other areas may not experience these benefits. In particular, MOs that would adversely affect resident fish in the upper Basin, such as MO2 and MO4, may have adverse effects on recreational resources for tribes in those areas.

# 3.12 WATER SUPPLY

## 3.12.1 Introduction and Background

The mainstem Columbia River, lower Snake River, Clearwater River, Kootenai River, Pend Oreille River, and Flathead River (the study rivers) provide water for millions of people and irrigated agriculture in Oregon, Washington, Idaho, and Montana. Water is pumped from the reservoirs of 9 of the 14 Federal Projects: Grand Coulee, Lower Granite, Lower Monumental, Little Goose, Ice Harbor, McNary, John Day, The Dalles, and Bonneville. Annually, about 7 Maf of water is supplied for irrigation, drinking water, and other municipal and industrial (M&I) needs (USGS 2017).

This section describes both the physical and socioeconomic existing conditions relating to water supply. Water supply is defined as the water used for the irrigation of crops as well as municipal and industrial uses. It also describes the environmental consequences resulting from the alternatives presented in Chapter 2. The physical existing condition description quantifies the irrigated lands and M&I needs associated with potentially affected areas. The socioeconomic existing condition description outlines social and economic conditions that could potentially be affected by changes to the physical existing condition for water supply.

The purpose of the water supply analysis is to evaluate the effects of operational and structural measure changes on current water supply obligations as described in the No Action Alternative. This should not be confused with the future water supply measures that are intended to explore the effect of diverting additional water on the flow and stage in the rivers.

About 1,393,000[1] acres are irrigated with water diverted within the study area. Growers in the potentially affected areas depend on irrigation to produce a wide variety of crops, including alfalfa, small grains, vegetables, fruits, and wine grapes.

About 5 percent[2] of the Columbia River Basin's water is diverted for agriculture. Irrigation water is diverted directly from the rivers and from the reservoirs behind storage and run-of-river projects, and is also pumped from groundwater wells. Diversions can vary from year to year and from month to month in response to varying weather and hydrologic conditions. A portion of the diverted water can travel back into the rivers and is known as irrigation return flow.

Though not all of these areas would be affected by potential changes to operations and maintenance of the CRS, irrigation throughout the projects is described here for context.

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[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).

#### *3.12.1.1 Federal Irrigation Projects*

Grand Coulee and Hungry Horse, operated by Reclamation, are the only projects of the 14 that are authorized to store water for irrigation. Grand Coulee stores water for the Columbia Basin Project; Hungry Horse does not currently store water for irrigation despite its authorization to do so.

At Grand Coulee, the water is pumped up approximately 300 vertical feet from behind the dam at Lake Roosevelt to a feeder canal that delivers water to Banks Lake, where it is stored and eventually released and distributed by canal to irrigators within the Columbia Basin Project. The Columbia Basin Project has water rights and previous NEPA compliance to deliver 3.248 Maf[3] of irrigation water to 720,000 acres[4] in Grant, Adams, Walla Walla, and Franklin Counties. Some of these acres have not yet been developed, so past measured deliveries are smaller than this volume. The Burbank pumps in the McNary Reservoir also supply about 23,000 acre-feet of water to the Columbia Basin Project.

The Chief Joseph Project, operated by Reclamation, pumps water from the Columbia River below the Corps' Chief Joseph Dam. The project was authorized over many years (versus all at once, which is more common) with authorizations totaling 33,050 acres (some of these acres have been transferred outside of the Federal project). Currently, 97,920[5] acre-feet of water is delivered to 28,800 Federal project acres.[6]

#### *3.12.1.2 Non-Federal Irrigation Withdrawals*

Non-Federal parties divert water for irrigation at many locations within the study area. Extensive areas of irrigated agriculture have developed near the reservoirs behind the four lower Columbia River dams (Bonneville, John Day, The Dalles, and McNary) and the reservoir behind Ice Harbor Dam on the lower Snake River. The projects are authorized for irrigation, but no water is stored for irrigation and none of the projects have specific features to accommodate irrigation, and there are no irrigation contracts with the Federal government. They are run-of-river projects that maintain elevated reservoir levels primarily for power generation and navigation. The exception is John Day, which maintains a slightly higher reservoir elevation than is needed for navigation to ensure that irrigation pumps can operate. Both small pumps and large-scale pumping plants that serve multiple users withdraw water from the reservoirs for pumping to fields. This water is diverted under natural or live flow rights issued by the states.

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[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.

#### *3.12.1.3 Municipal and Industrial Water Supply*

Use of water from the study area to meet M&I water supply needs is approximately 0.5 percent[7] of the annual flow in the Columbia River Basin, which is about one tenth of the amount used for irrigation. Some cities and industries divert water from the river system, but these diversions are small to the point of being unmeasurable when compared to the total flow in the system. Most of this water is diverted under flow rights issued by the states.

The largest M&I water withdrawals from the lower Snake and lower Columbia Rivers are concentrated on or near the Lower Granite and McNary Reservoirs. Municipal water users withdrawing directly from the McNary Reservoir include the cities of Hermiston, Richland, Kennewick, and Pasco. Industrial water users, including the Port of Umatilla, also have intakes nearby. The City of Lewiston and the Potlatch Corporation have water supply intakes on the Clearwater River above Lower Granite Dam. The Columbia Basin Project has water rights to deliver 70,000 acre-feet of M&I water to its customers.

#### *3.12.1.4 Area of Analysis*

The scope of this study is limited to the regions in the study area where operational or structural changes in the alternatives have the potential to affect the ability to supply water for agriculture and M&I purposes. Only the regions and associated lands where the analysis showed a limitation in the ability to deliver water were further analyzed for socioeconomic effects.

The H&H models assume that the current diversion volume[8] of water for irrigation and M&I is delivered in all years and for all alternatives. As a result, the flow in the river in all years and for all alternatives reflects what would occur when all current irrigation and M&I demands are met and would not appear to be affected. As long as water surface elevations do not change substantially, it is assumed that these deliveries can be made with current infrastructure. However, changes in reservoir elevation such that water could not physically be diverted could affect the ability to deliver water. In addition, reservoir elevations could also affect efficiency in terms of the energy required to pump water both from surface and groundwater pumps.

Both the modeling analysis and the measure descriptions indicated which regions would have effects to reservoir elevations such that water could no longer be delivered.

**FUTURE WATER SUPPLY MEASURES**

Socioeconomic effects were not evaluated for increased pumping from Grand Coulee or increased water supply from the Hungry Horse or Chief Joseph Projects for the future water supply measures. The details of how and where this water would be used is subject to an as-yet

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[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.

undefined future Federal action and additional NEPA analysis would be needed prior to taking any such action. Additional information is provided in Appendix N, *Water Supply*.

The effects of delivering this water on flow and stage are described in sections addressing resources that are affected by changes to flow and stage such as H&H, Water Quality, and Fish. Any effects to the ability to deliver water supply are the combined effects of the measures in each MO, which may include the future water supply measures.

## 3.12.2 Affected Environment

### *3.12.2.1 Physical Water Supply*

This section describes the physical aspects of the existing conditions for water supply, including the quantification of water needed for irrigation, municipal, and industrial supply; the locations where water is diverted from surface water and from groundwater wells within 1 mile of the river; and the lands that use that water for irrigation.

Only the projects that may be affected in each region are described. In some cases, there is not enough data to quantify the effects to each region, particularly with respect to pump operating elevations. Qualitative statements are provided in these instances.

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

In Region A, there are diverters of irrigation and M&I water throughout the region, particularly in the river reaches below the dams (Table 3-266). Though there are many diversion points, these are primarily small private diverters that individually do not use large quantities of water. These surface water pumps could be impacted if the flow in the river decreases and reduces the stage to the point where the pumps either cannot operate or operate less efficiently. There is limited data available about these pumps, so qualitative assessments are made about possible effects.

In addition, there are groundwater wells within 1 mile of the rivers (Table 3-266). Given the likely small change in river stage due to changes in outflow, it is anticipated that these will not be affected in this Region.

**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 |

### Irrigation

In Region A, approximately 675,000 acre-feet of water is diverted on an average annual basis for irrigation, with a portion of that water returning to the river as return flows (Bonneville 2011b). This water is supplied primarily from the rivers below the projects and is regulated by state water rights law.

### Municipal and Industrial

In the counties surrounding Region A, approximately 31,000 acre-feet of water is diverted for M&I purposes from both surface and groundwater (USGS 2018a; Table 3-267).

**Table 3-267. Summary of Municipal and Industrial Use by County for Surface and Groundwater in Counties that Border the River Reaches below the Columbia River System 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*** |

1/ Kootenai County was not included because most of the M&I use in that county was near Coeur d'Alene, which is not within the study area.
Source: USGS 2018a

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

In Region B, the largest diversion of water occurs from Lake Roosevelt at the John W. Keys Pumping Plant, which pumps up to 3.318 Maf annually for irrigation and M&I on the Columbia Basin Project. In addition, there are small pumps that divert for irrigation and M&I purposes from Lake Roosevelt (Table 3-268). These surface water pumps vary in capacity, location, and water surface elevation requirement. Specific data on individual pump elevations is not readily available. That being said, the pump operating elevations can be inferred from historical reservoir elevations by assuming the pumps could have operated for their designated purpose under historical reservoir elevations.

In addition, there are groundwater wells within 1 mile of these reservoirs that pump for irrigation and M&I purposes. These wells have the potential for groundwater connectivity with the water in the reservoirs, i.e., changes in water surface elevation in the reservoirs may translate to changes in water surface elevation in the wells. However, there is not enough data to determine which of the wells are hydraulically connected and therefore the extent of the possible effects from changing reservoir elevations.

**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 |

**Irrigation**

In Region B, in addition to the 3.318 Maf delivered to the Columbia Basin Project, up to 35,500 acre-feet of water is delivered for irrigation annually, with a portion of the water returning to the river as return flows (Bonneville 2011b). That water is used to grow a variety of crops, including fruit, small grains, hay, grapes, and irrigated vegetables.

**Municipal and Industrial**

In the counties surrounding the reaches in Region D that could be impacted by changes to operations and maintenance, about 16,860 acre-feet are diverted for M&I purposes (USGS 2017; Table 3-269). The M&I users in this region are largely small private users with individually owned pumps.

**Table 3-269. Summary of Municipal and Industrial Use by County for Surface and 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*** |

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

At Ice Harbor, Lower Monumental, Little Goose, and Lower Granite Projects, numerous irrigation and M&I pumps are used for surface water diversions from the various reservoirs

(Table 3-270). These pumps vary in capacity, location, and water surface elevation requirements. In addition, there are groundwater wells within 1 mile of these reservoirs that have the potential to have groundwater connectivity with the water in the reservoirs. If these reservoir elevations were to change, there is potential for the groundwater table to change. The data in Table 3-270 summarizes the number of pumps and wells within 1 mile of the lower Snake projects. Specific data on individual pump elevations is not readily available. That being said, average pump elevations, and thus operational requirements, can be inferred by referring to the minimum operating pool (MOP) elevations for individual reservoirs as listed in Table 3-271. In addition, specific information about the connectivity of the groundwater wells with the reservoirs is not available, so it is possible that some of these wells will not be affected.

**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 |

Source: Reclamation 2019

**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 |

**Irrigation**

In Region C, an average of approximately 316,000 acre-feet of water is diverted annually for irrigation, with a portion of that water returning to the river as return flows (Bonneville 2011b). The water is pumped from the reservoirs behind Lower Granite, Lower Monumental, Little Goose, and Ice Harbor dams. These projects are run-of-river dams that are operated for the primary purposes of hydropower generation and navigation. Non-Federal water users advantageously use the already-elevated reservoirs to pump water for irrigation. That water is used to grow a variety of crops and livestock, including fruit trees, grapes, potatoes, corn, and grains.

Cattle watering corridors provide access across government property for cattle to water from the lower Snake River projects. These corridors are fenced off down to the riverbank. Rights to establish corridors were established as reserved cattle watering easements in the acquisition deeds. There are 45 instances of reserves that allow for one or more corridors to be established for cattle water purposes. Fifteen of these reserves are located at Lower Monumental, 15 are located at Little Goose, 11 at Ice Harbor, and 4 at Lower Granite (Corps 2019).

**Municipal and Industrial**

In the counties surrounding Region C, approximately 21,330 acre-feet of water is diverted for M&I purposes (USGS 2018a; Table 3-272). The largest M&I water withdrawals from the study area are concentrated on or near the Lower Granite Reservoir, though there are other small private users along the river throughout the region.

**Table 3-272. Summary of M&I Use by County for Surface and Groundwater in Counties that 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*** |

1/ Does not include: Columbia County, Whitman County, or Franklin County, Washington. The majority of M&I activity in these counties appears to be on tributaries outside the scope of this study area. Removed Walla Walla County, Washington, because most of the M&I activity for this county was in the city of Walla Walla, which is outside of the study area.

Source: USGS 2018a

The primary users of the Lower Granite Reservoir are the Cities of Lewiston and Clarkston and the Potlatch Corporation. The City of Lewiston supplies drinking and irrigation water partly from the Clearwater and partly from six groundwater wells (Lewiston 2018). Asotin County PUD supplies water to the City of Clarkston from groundwater wells (Asotin 2018).

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

The data in Table 3-273 summarizes the number of pumps in the river and groundwater wells within 1 mile of the McNary and John Day Reservoirs. As in Region C, the pumps vary in capacity, location, and water surface elevation requirements. In addition, the groundwater wells within 1 mile of these reservoirs have the potential for changes in the shallow aquifer as elevations in the reservoir change, as they could be hydraulically connected to the reservoir; it is possible that some are not hydraulically connected but data is not available for verification.

**Table 3-273. Number of Irrigation and Municipal and Industrial Diversions (Pumps and Wells) 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 |

**Irrigation**

In Region D, an average of approximately 530,000 acre-feet of water is diverted annually for irrigation, with a portion of water returning to the river as return flows (Bonneville 2011b). The John Day Project is operated to a minimum irrigation pool of 262.5 feet NGVD29 (265.7 feet NAVD88) elevation to allow non-Federal water users to pump water for irrigation. That water is used to grow a variety of crops, including potatoes, fruit trees, grapes, corn, and grains.

**Municipal and Industrial**

In the counties surrounding Region D that could be impacted by changes to operations and maintenance, about 34,400 acre-feet are diverted for M&I purposes (USGS 2017; Table 3-274). Cities surrounding the McNary and John Day Reservoirs get their drinking water from both surface and groundwater sources. There are also many pumps and wells that list domestic water as a use, indicating that there are private users who may be using water from the river, and/or shallow groundwater, for drinking water.

**Table 3-274. Summary of Municipal and Industrial Use by County for Surface and 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*** |

1/ Walla Walla County is excluded because most of the drinking water is likely in the city of Walla Walla. The Port of Umatilla and the City of Umatilla are the only entities used for Umatilla County (data from Oregon Water Resources Department water use reports).
Source: USGS 2017

### *3.12.2.2 Socioeconomic Water Supply*

The water supply socioeconomic analysis area is described below for Regions A, B, C, and D. In some instances, the socioeconomic analysis regions (Regions A through D) were further delineated into subsets or reaches for describing water supply–related socioeconomic effects. These reaches are based on where the physical water supply effects occur. These analysis areas are specifically used to describe the regional economic effects and the other social effects. The social welfare effects are described from a national standpoint; however, data to measure these effects is specific to these reaches. Table 3-275 summarizes how the water supply socioeconomic analysis areas are organized.

**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<br>Franklin<br>Grant<br>Lincoln | WA<br>WA<br>WA<br>WA | Adams, WA<br>Franklin, WA<br>Grant, WA<br>Lincoln, WA | Columbia Basin Project |
| Region C | Lower Granite | Nez Perce<br>Asotin | ID<br>WA | Nez Perce, ID<br>Garfield, WA<br>Whitman, WA<br>Asotin, WA | Lower Granite and Little Goose |
| | Little Goose | Garfield<br>Whitman | WA<br>WA | | |
| | Ice Harbor | Franklin<br>Walla Walla | WA<br>WA | Columbia, WA<br>Franklin, WA<br>Walla Walla, WA | Ice Harbor and Lower Monumental |
| | Lower Monumental | Columbia<br>Franklin<br>Walla Walla | WA<br>WA<br>WA | | |
| Region D | John Day | Benton<br>Klickitat<br>Morrow<br>Umatilla | WA<br>WA<br>OR<br>OR | Benton, WA<br>Klickitat, WA<br>Morrow, OR<br>Umatilla, OR | John Day |

Economic activity is commonly measured through employment, labor income, and industry output (sales). Employment measures the number of jobs (full time and part time) related to each of the industry sectors of the regional economy. Labor income is the sum of employee compensation and proprietor income. Industry output (sales) represent the value of goods and services produced by businesses within a sector of the economy. These measures are described below for each area that was modeled for the water supply socioeconomic analysis. More detail is found in Appendix N, *Water Supply*.

The data used to derive these measurements was obtained from IMPLAN (IMpact analysis for PLANning). This analysis used 2017 IMPLAN data for the counties which encompass the analysis areas. IMPLAN data files are compiled from a wide variety of sources including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor, and U.S. Census.

## REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

The water supply socioeconomic analysis is comprised of Idaho's Bonner County. Potential water supply impacts may impact M&I users within this area.

Employment in the Bonner County area is approximately 22,000 jobs (full time and part time). The largest number of jobs is generated by activities related to the retail trade sector (12.47 percent of total regional employment). The government sector ranks second in terms of overall number of jobs in the analysis area, with 10.77 percent of total regional employment.

Labor income in Bonner County is estimated at $800,280. The manufacturing and government sectors are the largest contributors to labor income (17.87 percent and 17.09 percent, respectively).

Output (sales) equals $3,235,100. The manufacturing industry leads the Bonner County in output or sales at 29.36 percent of the total output (sales). The real estate sector ranks second at 11.92 percent.

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

The water supply socioeconomic analysis encompasses Adams, Franklin, Grant, and Lincoln Counties in the state of Washington. Reclamation's Columbia Basin Project is located within this region.

Employment in the Columbia Basin Project area (four counties) is approximately 104,700 jobs (full time and part time). Activities related to the agricultural sector generate the largest number of jobs, with 21.56 percent of total regional employment. The government sector ranks second in terms of overall number of jobs in the Columbia Basin Project area, with 16.0 percent of total regional employment. Employment within the agricultural sector is primarily related to fruit farming (37.42 percent), support activities for agriculture (31.26 percent), and vegetable farming (15.38 percent).

Labor income in this Columbia Basin Project area is estimated at $5,806,460. The agricultural and government sectors make the largest contribution to labor income (27.01 percent and 19.19 percent, respectively). The manufacturing sector ranks third, making up 10.33 percent of total labor income in the Columbia Basin Project area.

Output (sales) equals $17,645,040. The manufacturing industry leads the Columbia Basin Project area in output or sales at 24.80 percent of the total output (sales). The agricultural sector ranks second at 20.07 percent.

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

Water supply socioeconomic effects for Region C were modeled in two different areas. The Ice Harbor and Lower Monumental area is composed of Washington's Columbia, Franklin, and Walla Walla Counties. The Lower Granite and Little Goose area is made up of Idaho's Nez Perce County and Washington's Asotin, Garfield, and Whitman Counties.

**Ice Harbor and Lower Monumental**

Employment in the Ice Harbor and Lower Monumental analysis area is approximately 81,500 jobs (full time and part time). The government sector's activities generate the largest number of jobs (15.26 percent of total regional employment). The agricultural sector ranks second in terms of overall number of jobs in the analysis area, with 14.7 percent of total regional employment. Health and social services related employment ranks third, making up 10.13 percent of total regional employment. Employment within the agricultural sector is primarily related to fruit farming (36.23

percent), vegetable farming (16.52 percent), and all other crop farming (which include grapes; 11.84 percent).

Labor income in this area is estimated at $4,270,650. The government and agricultural sectors make the largest contribution to labor income within the area (20.4 percent and 17.9 percent, respectively). The manufacturing sector ranks third, making up 10.72 percent of total labor income in the area.

Output (sales) equals $12,964, 430. The manufacturing industry leads the area in output (sales) at 26.64 percent of the total. The agricultural sector ranks second at 11.51 percent.

**Lower Granite and Little Goose**

Employment in the Lower Granite and Little Goose area is approximately 63,000 jobs (full time and part time). Activities related to the government sector generate the largest number of jobs, with 24.33 percent of total regional employment. The manufacturing sector ranks second in terms of overall number of jobs in the analysis area, with 12.61 percent of total regional employment. Employment related to health and social services ranks third, making up 10.66 percent of total regional employment.

Employment related to the agricultural sector makes up 4.3 percent of the total employment in the area. Employment within the agricultural sector is mostly related to grain farming at 33.69 percent, with all other crop farming at 20.91 percent.

Labor income in this area is estimated at $3,235,000. The largest contributions to labor income are made by the government (30.93 percent) and manufacturing (18.12 percent) sectors. The health and social services sector ranks third, making up 11.43 percent of total labor income in the area.

Output (sales) equals $10,069,890. The manufacturing industry leads the area in output (sales) at 30.97 percent of the total. The agricultural sector ranks second at 14.61 percent.

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

The potential water supply socioeconomic effects in Region D were measured in the John Day area which is composed of Oregon's Morrow and Umatilla Counties and Washington's Benton and Klickitat Counties.

Employment in the John Day area is approximately 165,455 jobs (full time and part time). Activities related to the government sector generate the largest number of jobs, with 12.88 percent of total regional employment. The agricultural sector ranks second in terms of overall number of jobs in the analysis area, with 11.12 percent of total regional employment. Employment within the agricultural sector is related to support activities for agriculture (30.88 percent), fruit farming (29.60 percent), and vegetable farming (14.59 percent).

Labor income in this area is estimated at $9,788,130. The government and professional, scientific, and technical services sectors make the largest contribution to labor income (15.09 percent and 13.02 percent, respectively).

Output (sales) equals $27,709,430. The manufacturing industry leads the area in output (sales) at 17.24 percent of the total. The professional, scientific, and technical services sector ranks second at 9.49 percent.

### 3.12.3 Environmental Consequences

Water supply in the affected regions is largely driven by water surface elevation, where either the reservoir elevation is high enough for the pumps to operate or it is not. Efficiencies (i.e., the amount of energy required to pump a volume of water) can also be affected by reservoir elevation; this analysis only considers negative effects to efficiencies in reaches where reservoir elevations drop below historical operating elevations but pumps are still able to operate.

Anticipated water surface elevation based on measure descriptions in the affected reaches is used as a key indicator to assess environmental consequences of each measure. For example, the Ice Harbor Project has a minimum operating elevation of 437 feet NGVD29. In some cases, the intended operation described in a measure could not be modeled; in those cases, the described operation in the measure was used for the water supply analysis. Pumps in this reservoir were designed to work with this MOP. If the reservoir was lowered because the dam was breached (as analyzed in MO3), these pumps would no longer be able to operate. See Appendix N, *Water Supply,* for additional information on key modeling assumptions that affect the water surface elevations.

The co-lead agencies went to extensive effort to identify lands irrigated with water from the potentially affected reaches. The co-lead agencies used available water rights place-of-use and point-of-diversion area to identify lands that received water from individual reaches. USDA data was then used to identify crops that had been grown on those lands between 2013 and 2017. Detailed information about how this data was derived can be found in Appendix N, *Water Supply*, along with the limitations of this data.

Estimates of pumping costs for the John W. Keys Pumping Plant (pumping from Lake Roosevelt for the Columbia Basin Project) were calculated using a spreadsheet that calculates pump volume and the energy required to pump that volume with respect to reservoir elevation. The energy (current average) required to pump 1 acre-foot of water from Lake Roosevelt to Banks Lake is 333 kilowatt hours (kWh) and the increase in energy to pump the same 1 acre-foot of water 1 foot higher (i.e., if Lake Roosevelt were 1 foot lower for an alternative) is an additional 1.19 kWh of energy. The current cost of energy for the Columbia Basin Project is $0.003616 per kWh using the Columbia Basin Diversion Rate Methodology and Process of CY 2015–2019.

The socioeconomic analysis was driven by the physical water supply effects. If changes to the water surface elevations affect the ability of the pumps to continue to deliver water to the irrigated lands, this, in turn, affects the value of crop production from those lands. The areas of irrigated lands receiving water from these pumps were estimated using the USDA Cropland Data Layer. These acreage estimates were the basis for cropland acreages and cropping patterns in the socioeconomic analysis. The potential effects to M&I water deliveries were also analyzed based on the physical water diversions that may be affected. These analyses are discussed in detail in Appendix N, *Water Supply*.

The proposed alternatives were analyzed using two economic measures: (1) the social welfare effects, or direct effects; and (2) the regional economic effects. A regional economic effects analysis is distinctly different from the social welfare analysis. The regional impact analysis is a measure of regional activity, whereas the social welfare analysis is a measure of economic benefits to the nation as a whole. Additionally, the socioeconomic analysis evaluated the MOs for other social effects.

The results of the social welfare analysis and the regional economic impact analysis are not directly comparable because they do not measure the same effects. The social welfare analysis measures net benefits, which represent the value of a resource or resource-related activity to society. The regional impact analysis measures regional effects, which are flows of money (or employment) into or out of a defined region. The regional effects from an action may result in substantial increases in income or employment within a specific region but may generate little or no benefits to society at the national level. It is also possible that an action may result in reduced regional output and income in a particular area while generating positive benefits to the nation as a result of potential environmental enhancement activities or other improvements that are not translated into actual money flows.

The IMPLAN model was used to estimate the regional economic effects to employment, output (sales), and labor income. Employment measures the number of jobs (full-time, part-time, and temporary) related to each industry sector of the regional economy. Labor income is the sum of employee compensation and proprietor income. Industry output (sales) represent the value of goods and services produced by businesses within a sector of the economy.

IMPLAN is a static model that estimates impacts for a snapshot in time when the impacts are expected to occur, based on the makeup of the economy at the time of the underlying IMPLAN data. IMPLAN measures the initial impact to the economy but does not consider long-term adjustments as labor and capital move into alternative uses. This approach is used to compare the alternatives. Realistically, the structure of the economy will adapt and change; therefore, the IMPLAN results can only be used to compare initial relative changes between the No Action Alternative and MOs and cannot be used to predict or forecast future employment, labor income, or output (sales).

While the social welfare effects and regional economic effects are focused on quantifying and monetizing (when possible) the effects of the MOs, other social effects will consider those more intangible or qualitative effects that could be experienced at an individual, group, or community level in order to provide a more complete understanding of potential effects. Other social effects may include urban and community effects not described as part of the economic analyses.

There are no anticipated effects to water supply in Canada under any alternative.

### *3.12.3.1 No Action Alternative*

The No Action Alternative was designed to continue to supply water to existing users as it has in the recent past. Because the model assumes that an average diversion representative of current conditions was diverted every year, regardless of conditions, water supply from surface water resources would not be impacted under the No Action Alternative.

For there to be effects to groundwater deliveries, the elevations in the streams and reservoirs would have to drop below historical elevations. For the No Action Alternative, it is not anticipated that the elevations in any of the streams or reservoirs would affect nearby groundwater wells because the operation is representative of the historical range.

Socioeconomic results for the No Action Alternative are described here for Regions A, B, C, and D for a comparative baseline.

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

In Region A under the No Action Alternative, approximately 675,000 acre-feet of water would be diverted on an average annual basis for irrigation with a portion of that water returning to the rivers and return flows (Bonneville 2011b). In the counties surrounding Region A, approximately 31,000 acre-feet of water would be diverted for M&I purposes from both surface and groundwater (USGS 2018a; Table 3-).

In Region A, the socioeconomic effects for the MO conditions were estimated as the increment between the No Action Alternative and the MO conditions. Therefore, effects were not estimated for the No Action Alternative.

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

In Region B under the No Action Alternative, approximately 3.318 Maf would be diverted from Lake Roosevelt at the John W. Keys Pumping Plant for agricultural and M&I use to the Columbia Basin Project with a portion returning to the river as return flow (Bonneville 2011b). An additional 35,500 acre-feet would be diverted from Lake Roosevelt by non-Federal users for irrigation and an additional 16,860 acre-feet for M&I uses (USGS 2018a; Table 3-269).

In Region B, the socioeconomic effects for the MO conditions were estimated as the increment between the No Action Alternative and the MO conditions. Therefore, effects were not estimated for the No Action Alternative.

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

In Region C under the No Action Alternative, an average of approximately 316,000 acre-feet of water would be diverted annually for irrigation, with a portion of that water returning to the river as return flows (Bonneville 2011b). In the counties surrounding Region C, approximately 21,330 acre-feet is diverted for M&I purposes (USGS 2018a; Table 3-272).

**Social Welfare Effects**

***Irrigation***

This analysis used a land value approach to estimate benefits or social welfare effects related to irrigation. The irrigation social welfare effect was based on the land's income-producing capability from farm production. The land value method calls for a with and without comparison of irrigated and non-irrigated lands. When using land values to estimate the social welfare effects of irrigation water, the land values used for estimating the value of the water must be based on the land's income-producing capability from crop production. Appraisers generally refer to land values based on the land's income-producing capability as "value in use" rather than a market value (American Society of Farm Managers and Rural Appraisers 2000).

The analysis used two datasets to estimate the irrigation benefit values. The first estimate relied on County Assessor estimates of farm-use values. The second estimate used USDA farmland value survey estimates for Washington.

Walla Walla County data was used for the land value approach. Almost 80 percent of the lands in the analysis area are in Walla Walla County. The Walla Walla County Assessor's Office provided an extensive public dataset related to assessed values, along with GIS mapping. Based on this available data and the location of the lands, Walla Walla County Assessor data was considered representative for the analysis area.

The productive value of land varies depending upon quality and location. Land parcels are classified based on quality and productivity. This analysis used Class 1 lands for estimating the productive use of irrigated land (with condition) and dryland pasture use values (without condition). Table 3-276 shows the benefit value calculation in 2019 dollars for the "with" and the "without" conditions using the assessor's data. Class 1 land generally has soils that have few limitations restricting their use. Highly valued crops are often grown on Class 1 land, which is appropriate for this analysis given the cropping pattern within this analysis area. The USDA farmland values are used for a comparison. The USDA values are state-level averages for irrigated land of unknown soil classification.

**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 |

The social welfare effect or economic value for irrigation water (per acre) is the difference between the Class 1 value less the dryland value in 2019 dollars ($353.74/acre). The Walla Walla County Assessor data estimated the dryland rental rate (see Appendix N, *Water Supply* for discussion) as less than $2 per acre; therefore, it was assumed to be zero for the purposes of this analysis. The per-acre value was multiplied by the total number of acres under the No Action Alternative (47,926 acres). The acreage total includes both socioeconomic analysis areas within Region C (47,840 acres in the Ice Harbor and Lower Monumental area; 86 acres in the Little Goose and Lower Granite area)[9]. The annual values were discounted over the 50-year period using the discount rate of 2.75 (2020 Federal planning rate) to calculate the total present value. The total present value was then amortized over the same 50-year period and at the same discount rate to calculate the annual equivalent benefit value. The present value equals $ 458,099,362 (annual equivalent value is $16,953,343). By contrast, using the USDA farmland values, the present value equals $331,770,447 (annual equivalent value is $12,278,162). These calculations are shown in Table 3-277.

**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 |

***Municipal and Industrial***

The effects for the MO conditions were estimated as the increment between the No Action Alternative and the MO conditions. Therefore, effects were not estimated for the No Action Alternative.

**Regional Economic Effects Analysis**

The regional economic effects analysis estimated effects in two separate analysis areas within Region C. The Ice Harbor and Lower Monumental socioeconomic analysis area includes the following counties in Washington State: Columbia, Franklin, and Walla Walla. The Lower Granite and Little Goose socioeconomic analysis area includes Nez Perce County in Idaho and Asotin, Garfield, and Whitman Counties in Washington.

***Irrigation – Ice Harbor and Lower Monumental Dams***

The available water rights place-of-use and point-of-diversion data was used to identify lands that receive water from these reaches, as discussed in Section 3.12.1.1. Table 3-278 shows the estimated gross value of production for the crops grown in the Ice Harbor and Lower Monumental socioeconomic area. The No Action Alternative supports approximately 47,840 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.

grains, irrigated vegetables, grapes, and hay. According to the National Agricultural Statistics Service (NASS), the total fruit crop acreage in Columbia, Franklin, Walla Walla county equals approximately 34,000 acres for 2017. The fruit crop acreage in the Ice Harbor and Lower Monumental socioeconomic area (a smaller subset of the three counties) accounts for 15,800 acres or 46 percent of the total fruit acreage in all three counties. The total grape acreage, according to NASS, is approximately 5,500 acres for 2017, compared to 3,000 acres of grapes (55 percent of the all the grape acreage in the entire three counties), and based on these statistics approximately half of the total fruit crop and grape acreage in all of Columbia, Franklin, and Walla Walla Counties.

The gross value of production was calculated for each representative crop and was run through IMPLAN to estimate the regional effects for this alternative (Appendix N, *Water Supply*) describes how the gross value of production was derived). The regional effects include estimated employment, labor income, and output (sales) stemming from the gross value of production.

The No Action Alternative would result in maintaining approximately 4,800 jobs (full-time, part-time, and temporary jobs) within the Ice Harbor and Lower Monumental analysis area. These jobs are the result of gross farm income generated from crop production on approximately 47,840 acres of farmland. These jobs account for approximately 5.9 percent of the total jobs in the analysis area as shown in the affected environment section. The fruit farming sector impacts of almost 2,800 jobs account for 57 percent of the impacted employment total of 4,800 jobs.

Labor income resulting from the implementation of the No Action Alternative would equal $232,000,000, or 5.4 percent of the total labor income in the area. Output (sales) would equal $460,500,000, or 3.6 percent of the total output in the area (Table 3-278).

**Table 3-278. Estimated Gross Value of Production and Associated IMPLAN Sector for the Ice 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** | |

***Irrigation – Lower Granite and Little Goose Area***

Effects in this area were not modeled due to the small number of acres (less than 90) that were shown to be impacted. This small number of acres would have a positive effect to employment, labor income, and output (sales); however, it is too small to measure using IMPLAN.

***Municipal and Industrial***

The effects for the MO conditions were estimated as the increment between the No Action Alternative and the MO conditions. Therefore, effects were not estimated for the No Action Alternative.

**Other Social Effects Analysis**

Other social effects capture additional effects that are not measured in the social welfare or regional economic effects analysis. For water supply, these may include rural lifestyle or regional growth opportunities. No effects to other social effects are anticipated under this alternative.

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

In Region D under the No Action Alternative, an average of approximately 530,000 acre-feet of water would be diverted annually for irrigation, with a portion of water returning to the river as return flows (Bonneville 2011b). In the counties surrounding Region D, about 34,400 acre-feet are diverted for M&I purposes (USGS 2018a; Table 3-274). In Region D, the socioeconomic effects for the MO conditions were estimated as the increment between the No Action Alternative and the MO conditions. Therefore, effects were not estimated for the No Action Alternative.

**SUMMARY OF EFFECTS**

Under the No Action Alternative, there would be negligible or no change from recent historical conditions with respect to water supply from surface water resources as well as from groundwater. In Region C, the social welfare effect of irrigation is estimated to be between $12.28 million and $16.95 million and the regional economic impact across nearly 48,000 acres of farmland that generates approximately 4,800 jobs, $232 million in labor income, and $461 million in total output (sales). In Region D, the effects were estimated as an increment between the No Action Alternative and MOs; therefore, there were no effects measured for the No Action Alternative.

### *3.12.3.2 Multiple Objective Alternative 1*

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

The reaches below Libby and Hungry Horse may experience lower river stage in some years due to decreased outflows; however, the lower stages are not anticipated to affect the pumps' ability to operate, either due to downstream backwater effects or because the change in water surface elevation would not be measurable in the stream. Therefore, it is anticipated that water deliveries will still occur.

## REGION B – GRAND COULEE AND CHIEF JOSEPH DAMS

In Region B, multiple measures impact reservoir elevations in Lake Roosevelt, which could impact the pump efficiency at the John W. Keys Pumping Plant. The plant will be able to operate at all elevations in order to deliver sufficient supply to the Columbia Basin Project but pumping costs could increase if reservoir elevations are lower than the No Action Alternative. Using the average reservoir elevations from MO1 as compared to the No Action Alternative, estimated pumping cost could increase by approximately $7,000 annually to deliver current water supply and by $10,000 annually to deliver the current plus additional water supply (see Water Supply Measures). The non-Federal users around Lake Roosevelt may also experience increased pumping costs, but the effect is expected to be small in comparison to the John W. Keys effect and is considered to be a negligible effect overall.

### Social Welfare Effects

#### *Irrigation*

This analysis assumes that the currently irrigated lands would remain in production. This level of production would require increased pumping costs. Due to the drawdown, pump efficiencies would change, requiring more energy to pump the same quantity of water to the irrigated lands. The analysis assumes an increase to pumping costs of $7,000 annually.

The annual pumping costs, which represent the additional pumping cost over the No Action Alternative, were discounted over the 50-year period of record using the 2020 Federal planning rate (2.75 percent). The annual equivalent value equals $7,000 ($189,000 total present value). This value represents a decrease in net farm income across the region under MO1.

### Regional Economic Effects Analysis

Increased pumping costs would result in lower net farm income across the region, which translates to farm households having less money to spend within the regional economy. IMPLAN was used to estimate the regional effects (employment, labor income, and output) resulting from less money being spent within the study area by farm households. The increased pumping cost was modeled in IMPLAN as a household income change. The lost employment, labor income, and output would result from an increase in pumping costs of $7,000 (annual equivalent), as described in the Social Welfare Effects section, above. The average annual employment impact was estimated to be a decrease in employment (less than 1 job), labor income ($1,000), and output or sales ($3,700). These losses are the result of less household spending within the region because income was assumed to decrease as a result of increased pumping costs.

**Other Social Effects**

Other social effects capture additional effects that are not measured in the social welfare or region economic effects analyses. There are no other social effects expected as a result of the change in pumping costs.

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

The reach below Dworshak may experience lower river stage in some years due to decreased outflows; however, the lower flows are not anticipated to affect the pumps' ability to operate, either due to downstream backwater effects or because the change in water surface elevation would not be measurable in the stream. Therefore, it is anticipated that water deliveries will still be able to occur.

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

No change from the No Action Alternative.

**SUMMARY OF EFFECTS**

Decreases to reservoir elevations and river stage due to operational measures in MO1 may cause negligible effects to pumping costs for water supply; however, the ability to deliver water for irrigation and M&I is not expected to be affected. See Appendix N, *Water Supply*, for more detail.

Changes in pumping cost may cause negligible effects to social welfare and regional economic effects and no other expected social effects in Region B.

***3.12.3.3 Multiple Objective Alternative 2***

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

The reaches below Libby and Hungry Horse may experience lower river stage in some years due to decreased outflows; however, the lower flows are not anticipated to affect the pumps' ability to operate, either due to downstream backwater effects or because the change in water surface elevation would not be measurable in the stream. Therefore, it is anticipated that water deliveries will still be able to occur.

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

In Region B, multiple measures impact reservoir elevations in Lake Roosevelt, which could impact the pump efficiency at the John W. Keys Pumping Plant. The plant will be able to operate at all elevations in order to deliver sufficient supply to the Columbia Basin Project but pumping costs could increase if reservoir elevations are lower than the No Action Alternative. Using the average reservoir elevations from MO1 as compared to the No Action Alternative, the estimated pumping cost could increase by approximately $10,000 annually to deliver the current water supply. The non-Federal users around Lake Roosevelt may also experience increased pumping costs but the impact is expected to be small in comparison to the John W. Keys impact.

**Social Welfare Effects**

***Irrigation***

This analysis assumes that the currently irrigated lands would remain in production. This level of production would require increased pumping costs. Due to the drawdown, pump efficiencies would change, requiring more energy to pump the same quantity of water to the irrigated lands. The analysis assumes an increase to pumping costs of $10,000 annually.

The annual pumping costs, which represent the additional pumping cost over the No Action Alternative, were discounted over the 50-year period of record using the 2020 Federal planning rate (2.75 percent). The annual equivalent value equals $10,000 ($270,000 total present value). This value represents a decrease in net farm income across the region under MO2.

**Regional Economic Effects Analysis**

Increased pumping costs would result in lower net farm income across the region, which translates to farm households having less money to spend within the regional economy. IMPLAN was used to estimate the regional effects (employment, labor income, and output) resulting from less money being spent within the study area by farm households. The increased pumping cost was modeled in IMPLAN as a household income change. The lost employment, labor income, and output would result from an increase in pumping costs that is expected to be $10,000 (annual equivalent) as described in the Social Welfare Effects section, above. The average annual employment impact was estimated to be a decrease in employment (less than 1 job), labor income ($1,500), and output or sales ($5,000). These losses are the result of less household spending within the region because income was assumed to decrease as a result of increased pumping costs.

**Other Social Effects**

Other social effects capture additional effects that are not measured in the social welfare or region economic effects analyses. There are no other social effects expected as a result of the change in pumping costs.

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

The reach below Dworshak may experience lower river stage in some years due to decreased outflows; however, the lower flows are not anticipated to affect the pumps' ability to operate, either due to downstream backwater effects or because the change in water surface elevation would not be measurable in the stream. Therefore, it is anticipated that water deliveries will still be able to occur.

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

No change from the No Action Alternative.

**SUMMARY OF EFFECTS**

Decreases to reservoir elevations and river stage due to operational measures in MO2 may cause negligible effects to pumping costs for water supply; however, the ability to deliver water for irrigation and M&I is not expected to be affected. See Appendix N, *Water Supply*, for more detail.

In Region B, changes in pumping cost may cause negligible effects to social welfare and regional economic effects and no expected other social effects.

#### *3.12.3.4 Multiple Objective Alternative 3*

MO3 includes measures that could affect availability of current water supply in Region C. This includes measures to breach dams in this region of the lower Snake River, where water is diverted for irrigation of lands in Washington. In Regions A, B, and D, decreases to reservoir elevations and river stage due to operational measures in MO3 may cause negligible effects to pumping costs for water supply; however, the ability to deliver water for irrigation and M&I is not expected to be affected. See Appendix N, *Water Supply*, for more detail.

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

The reaches below Libby and Hungry Horse may experience lower river stage in some years due to decreased outflows; however, the lower flows are not anticipated to affect the pumps' ability to operate, either due to downstream backwater effects or because the change in water surface elevation would not be measurable in the stream. Therefore, it is anticipated that water deliveries will still be able to occur.

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

In Region B, multiple measures impact reservoir elevations in Lake Roosevelt, which could impact the pump efficiency at the John W. Keys Pumping Plant. The plant will be able to operate at all elevations in order to deliver sufficient supply to the Columbia Basin Project, but pumping costs could increase if reservoir elevations are lower than the No Action Alternative. Using the average reservoir elevations from MO1 as compared to the No Action Alternative, the estimated pumping cost could increase by approximately $3,000 annually to deliver current water supply and by $4,000 annually to deliver current plus additional water supply (see Water Supply Measures). The non-Federal users around Lake Roosevelt may also experience increased pumping costs, but the impact is expected to be small in comparison to the John W. Keys impact.

**Social Welfare Effects**

***Irrigation***

This analysis assumes that the currently irrigated lands would remain in production. This level of production would require increased pumping costs. Pump efficiencies would change due to the drawdown, requiring more energy to pump the same quantity of water to the irrigated lands. The analysis assumes an increase to pumping costs of $3,000 annually.

The annual pumping costs, which represent the additional pumping cost over the No Action Alternative, were discounted over the 50-year period of record using the 2020 Federal planning rate (2.75 percent). The annual equivalent value equals $3,000 ($81,000 total present value). This value represents a decrease in net farm income across the region under MO3.

**Regional Economic Effects Analysis**

Increased pumping costs would result in lower net farm income across the region, which translates to farm households having less money to spend within the regional economy. IMPLAN was used to estimate the regional effects (employment, labor income, and output) resulting from less money being spent within the study area by farm households. The increased pumping cost was modeled in IMPLAN as a household income change. The lost employment, labor income, and output would result from an increase in pumping costs that is expected to be $3,000 (annual equivalent) as described in the Social Welfare Effects section, above. The average annual employment impact was estimated to be a decrease in employment (less than 1 job), labor income ($500), and output or sales ($1,500). These losses are the result of less household spending within the region because income was assumed to decrease as a result of increased pumping costs.

**Other Social Effects**

Other social effects capture additional effects that are not measured in the social welfare or region economic effects analyses. There are no other social effects expected as a result of the change in pumping costs.

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

MO3 included a structural measure (*Breach Snake Embankment*) that could affect water supply in this region by breaching the lower four Snake River dams. Currently and in the No Action Alternative, water is available from the reservoirs of these facilities and from groundwater that results from the reservoirs. The pumps that supply this water would no longer be operational once the dams were breached and the nearby groundwater elevations could be substantially impacted. Chapter 4 analyzes the socioeconomic effects of implementing this measure.

Approximately 48,000 acres are currently irrigated from surface water and groundwater in Region C, with average diversions estimated to be around 316,000 acre-feet (the diversions encompass those from the Palouse, lower Snake, and Clearwater Rivers, and thus are likely a high estimate of diversion for the potentially affected acreage). Currently and under the No Action Alternative, water is available from the pools of these four lower Snake River dams and from nearby groundwater. The pumps and wells that supply this water would no longer be operational once these dams were breached.

There are M&I pumps in the Lewiston area that would likely be impacted by this measure, along with other small M&I uses along the river. The co-lead agencies identified a total of 16 points of diversion from surface water with a water rights purpose listed as M&I, which may use up to 9,230 acre-feet per year (USGS 2018a).

The Corps evaluated 15 pumps on Lower Granite Reservoir and indicated that these pumps used approximately 40,000 acre-feet per year in 1996 (Corps 2002b), with the largest user being the Potlatch Corporation (now Clearwater Paper). It is unclear if this number is total consumptive use or only the amount diverted. Over the last 10 years, the Clearwater Paper Company has been reducing its use by treating the water and returning it to the river (Clearwater Paper 2019), which could account for the overall reduction in usage in the area.

Groundwater would likely be impacted by this measure, with groundwater elevations having the potential to drop by the entire height of the dams, i.e., up to 100 feet. This would affect well users in the region. The water supply team identified approximately 200 groundwater points of diversion that could be used for M&I or irrigation.

The Corps evaluated wells in this region (Corps 2002b) and reported a similar number of wells (228) recorded in the region. Of the 228 wells, 180 (79 percent) were found to be functioning and within the study area. Of these 180 wells, 38 were analyzed using well log data combined with topographic features, well depth, stratigraphy, and surface elevation to determine which would be affected by changes in river water surface elevation (Corps 2002b). The Corps found that 15 of these wells (40 percent) would need to be modified to continue operation under the dam breaching condition. Extrapolating that number to the 200 groundwater points of diversion within the study area results in 63 wells that could be affected in the region.

**Social Welfare Effects**

***Irrigation***

The Corps (2002b) report analyzed dam breaching and its effect on water supply. This analysis considered several system modifications that would allow for the continuation of water deliveries to existing farmlands. The report concluded that modifying the existing pump system was cost prohibitive. For the regional analysis, the report assumed that most of the irrigated acres of land receiving water from the current pumps would no longer be irrigated. The report assumed that 21 percent of the irrigated land might support the development of alternative water supplies to replace lost irrigation water. According to the report, the replacement water would be used to irrigate some of the fruit orchards and vineyards.

This analysis assumed that all irrigated acres receiving water from the current pumps would no longer be irrigated. This assumption was based on conversations with several extension agents in Washington and Oregon. The analysis assumed that there was not a suitable substitute water source and the annual rainfall would not support a dryland crop rotation such as a wheat/fallow operation. There was also concern that soil acidity may affect a dryland wheat/fallow operation on lands that previously supported fruit orchards and vineyards.

Assuming the entire 47,926 acres were no longer irrigated, the present value of the lost social welfare benefit under MO3 would be $458,099,362 (annual equivalent value is $16,953,343). In contrast, using the USDA farmland values, the present value of the lost social welfare benefits equal $331,770,447 (annual equivalent value is $12,278,162). These estimates are in 2019 dollars.

***Municipal and Industrial***

In Region C, approximately 21,330 acre-feet of M&I water diversions were estimated in Section 3.12.2.1, the Physical Water Supply affected environment. Two approaches were used to estimate the social welfare effects of the M&I water supply: the use of water market transaction data and the cost of an alternative water source that would provide the water supply. Generally, the M&I benefits are measured based on willingness to pay, or the dollar amount that an entity is willing to pay to obtain an acre-foot of water.

First, the observed market transaction values were analyzed to derive the value of the M&I water supply. The observed data was obtained from the Water Transfer Data Base presented by the Bren School at the University of California, Santa Barbara. This dataset relied on observation from various issues of the Water Strategist publication. The dataset includes water trades involving agriculture, urban, recreational, and environmental uses from 1987 to 2009. Water trades for urban use in Washington and Idaho were used. While the dataset was limited in the number of observations, it was used to show a comparison to the social welfare effects estimated using construction cost estimates for pump station and private well modifications.

A second approach for estimating the M&I benefits was based on an approach described in the P&Gs (Principles and Guidelines) involving using the cost of the most likely alternative. In other words, using the cost of the water supply alternative that would be implemented in the absence of the project as an estimate of benefits. This approach is acceptable only if the alternative is viable in terms of engineering feasibility and financial feasibility. For this approach, the estimated cost of pump modifications, as found in the Corps (2002b) report, was used.

As shown in Table 3-279, a weighted average of M&I per water acre-foot value was derived. The M&I water values were weighted using the estimated surface water and groundwater M&I diversions discussed in Section 3.12.2.1.

**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 |

The physical water supply analysis estimated that 21,330 acre-feet of water is diverted for M&I purposes. The social welfare effect (annual equivalent) is estimated as $5,849,112 ($274.22 per acre multiplied by 21,330 acre-feet).

The second approach to value the social welfare effects of the M&I water supply relied upon the estimated costs of pump and well modifications, which were taken from the Corps 2002b report. This analysis assumes that these modifications would be found feasible in terms of engineering and financing. These costs were estimated in 1998 dollars and indexed to 2019 using Reclamation's construction cost trends for pumping plants. Summaries of these costs are shown in Table 3-280 and Table 3-281.

**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 |

**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) |

To estimate the social welfare effects, the cost estimates were annualized assuming a 50-year period of analysis and a 2.75 percent discount rate (2020 Federal planning rate). As shown in Table 3-280, the annualized social welfare effects range from $4,894,800 to $7,617,700. On a per-acre-foot basis, the social welfare effects range from $229.48 to $357.14.

It should be recognized that the physical quantities of water are based on the water rights. This may lead to an overestimation of the actual water used. The estimates of social welfare effects of M&I water may be overstated.

**Regional Economic Effects**

***Irrigation – Ice Harbor and Lower Monumental Dams***

Assuming the entire 47,840 acres were no longer irrigated, gross value of production would decline by approximately $313,695,365, as described for the No Action Alternative.

Decreased production would result in the loss of employment, labor income, and output (sales) in the region equal to what was estimated under the No Action Alternative. Approximately 4,800 jobs (full-time, part-time, and temporary jobs) within the Ice Harbor and Lower Monumental socioeconomic area were estimated to be lost. These jobs account for approximately 5.9 percent of the total jobs in the area. The fruit farming sector impacts (almost 2,800 jobs) account for 57 percent of the impacted employment total (4,800 jobs). The implementation of MO3 would decrease labor income by $232,000,000 (5.4 percent of the total labor income in the areas). Output would decline by $460,500,000 (3.6 percent of the total out output).

As discussed in the No Action alternative, according to NASS, the total fruit crop acreage in Columbia, Franklin, and Walla Walla Counties equals approximately 34,000 acres for 2017. The fruit crop acreage in the Ice Harbor and Lower Monumental socioeconomic area (a smaller subset of the three counties) accounts for 15,800 acres or 46 percent of the total fruit acreage in all three counties. The total grape acreage, according to NASS, is approximately 5,500 acres for 2017 compared to 3,000 acres of grapes (55 percent of the all the grape acreage in the entire 3 counties). Based on these statistics, this alternative affects approximately half of the total fruit crop and grape acreage in all of Columbia, Franklin, and Walla Walla Counties.

***Irrigation – Lower Granite and Little Goose Dams***

Assuming the entire 90 acres were no longer irrigated, the gross value of crop production would decline relative to the No Action Alternative. Published yields and prices were not available in this area to measure the gross value of crop production. A decrease in agricultural production on these 90 acres would result in the loss of employment, labor income, and output (sales). These losses were too small to quantify.

***Municipal and Industrial***

The physical water supply analysis estimated that 21,330 acre-feet of water is diverted for M&I purposes. The social welfare effect (annual equivalent) is estimated as $5,849,112 ($274.22 per acre multiplied by 21,330 acre-feet). This value was estimated based on the wholesale price of M&I water; therefore, it was modeled in IMPLAN as a loss in household income. This decrease in household income would have a negative effect on the regional economy in terms of jobs, labor income, and output (sales). These effects were estimated as a loss of 55 jobs, $2,261,000 of labor income, and $7,518,000 of output (sales) annually.

### Other Social Effects

Other social effects (OSE) capture additional effects that are not measured in the social welfare or region economic effects analyses. For water supply, these may include rural lifestyle or regional growth opportunities. In Region C under MO3 conditions, approximately 48,000 acres were estimated to go out of production. These impacts include approximately half the total fruit farming and grape producing acres in the three counties. The changes in regional economic effects including employment may include other social effects associated with rural lifestyle or regional growth opportunities, particularly those associated with agricultural production and agricultural support services.

The overall change in M&I deliveries under MO3 would be relatively small compared to the entire region. These losses in delivery would be unlikely to affect population or regional growth opportunities in the study area.

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

Following the breaching of the lower Snake River dams, there would likely be sediment transported through the McNary and John Day Reservoirs (see Section 3.3, *River Mechanics*, for more information). The river mechanics modeling showed that at the location of the large pumps used for the Umatilla lands near RM 295, there would be fine-grained material that would reach the pumps. However, it should not affect that pump's ability to operate given that the intakes are 3 to 4 feet in diameter. Farther upstream, there are some private pumps that may be impacted by the fine-grained material. Though it would not impede their ability to deliver water, it would result in a need for more frequent maintenance.[10]

## SUMMARY OF EFFECTS

In Region B, changes in pumping cost may cause negligible effects to social welfare and regional economic effects and no other expected social effects.

Measures implemented under MO3 could affect delivery of current water supply in Region C and are expected to result in minor effects to social welfare and major effects to regional economics. This alternative includes measures to breach dams in this region of the lower Snake River, where water is diverted for irrigation of lands in Washington. This alternative would affect both surface water resources and groundwater. In Region C, it is assumed that none of the approximately 48,000 acres currently being irrigated would continue to be irrigated under MO3. This would result in a social welfare loss equivalent to the benefits under the No Action Alternative. As described for the No Action Alternative, this amounts to an annual equivalent value effect of between $12.28 million and $16.95 million (2019 dollars).

[10] Based on conversations with Reclamation's Umatilla Field Office Manager.

In addition to the social welfare losses to irrigation in Region C, under MO3 it is estimated that there would be additional social welfare losses associated with M&I water supply of between approximately $4.9 million and $7.6 million (annual equivalent values).

There would be adverse regional economic effects in Region C in terms of jobs, labor income, and output (sales). It is estimated that regional economic effects associated with the loss of nearly 48,000 acres of farmland equal approximately 4,800 jobs, $232 million in labor income, and $461 million in total output (sales). The regional effects related to municipal and industrial water supply were estimated as losses of 55 jobs, $2,261,000 of labor income, and $7,518,000 of output (sales) annually. Overall, these effects are expected to be major to the region.

In Region C, the changes in regional economic effects, including employment, may include major effects classified as other social effects where associated with rural lifestyle or regional growth opportunities, particularly those associated with agricultural production and agricultural support services.

Measures implemented under MO3 are expected to have minimal effects in Region D. The effects are expected to be limited to the requirement for more frequent maintenance of some private pumps in the upstream reach.

#### *3.12.3.5 Multiple Objective Alternative 4*

MO4 included one operational measure that would affect the ability to deliver water to meet current water supply. In Regions A, B, and C, decreases to reservoir elevations and river stage due to operational measures in MO4 may cause negligible to minor effects to pumping costs for water supply; however, the ability to deliver water for irrigation and M&I is not expected to be affected. See Appendix N, *Water Supply,* for more detail.

##### **REGION A - LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS**

The reaches below Libby and Hungry Horse may experience lower river stage in some years due to decreased outflows; however, the lower flows are not anticipated to affect the pumps' ability to operate, either due to downstream backwater effects or because the change in water surface elevation would not be measurable in the stream. Therefore, it is anticipated that water deliveries will still be able to occur. Lake Pend Oreille (the lake behind Albeni Falls Dam) could be up to 2.5 feet lower in the summer in some years. The change in elevation is not lower than the winter minimum; therefore, the pumps would still be able to operate but at a possibly higher pumping cost.

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

In Region B, multiple measures impact reservoir elevations in Lake Roosevelt, which could impact the pump efficiency at the John W. Keys Pumping Plant. The plant will be able to operate at all elevations in order to deliver sufficient supply to the Columbia Basin Project, but pumping costs could increase if reservoir elevations are lower than the No Action Alternative.

Using the average reservoir elevations from MO1 as compared to the No Action Alternative, estimated pumping cost could increase by approximately $72,000 annually to deliver current water supply and by $99,000 annually to deliver current plus additional water supply (see Water Supply Measures). The non-Federal users around Lake Roosevelt may also experience increased pumping costs, but the impact is expected to be small in comparison to the John W. Keys effect.

**Social Welfare Effects**

***Irrigation***

This analysis assumes that the currently irrigated lands would remain in production. This level of production would require increased pumping costs. Due to the drawdown, pump efficiencies would change, requiring more energy to pump the same quantity of water to the irrigated lands. The analysis assumes an increase to pumping costs of $72,000 annually.

The annual pumping costs, which represent the additional pumping cost over the No Action Alternative, were discounted over the 50-year period of record using the 2020 Federal planning rate (2.75 percent). The annual equivalent value equals $72,000 ($1,945,500 total present value). This value represents a decrease in net farm income across the region under MO4.

**Regional Economic Effects Analysis**

Increased pumping costs would result in lower net farm income across the region, which translates to farm households having less money to spend within the regional economy. IMPLAN was used to estimate the regional effects (employment, labor income, and output) resulting from less money being spent within the study area by farm households. The increased pumping cost was modeled in IMPLAN as a household income change. The lost employment, labor income, and output would result from an increase in pumping costs that is expected to be $72,000 (annual equivalent) as described in the Social Welfare Effects section, above. The average annual employment impact was estimated to be a decrease in employment (less than 1 job), labor income ($11,000), and output or sales ($38,000). These losses are the result of less household spending within the region because income was assumed to decrease as a result of increased pumping costs.

**Other Social Effects**

Other social effects capture additional effects that are not measured in the social welfare or regional economic effects analyses. There are no other social effects expected as a result of the change in pumping costs.

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

No change from the No Action Alternative.

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

MO4 included an operational measure that could affect water supply from the John Day Reservoir (the *Drawdown to MOP* measure) by lowering the minimum pool during the irrigation season by 1.5 feet to 261.0 feet NGVD29 (264.2 feet NAVD88). A decrease in water surface elevation by 1.5 feet would not be outside the range of recent historical operations, so it is possible that most, if not all, of the pumps would still be operational. However, anecdotal information suggests that some pumps might need modification to continue operation. Complete data is not available to analyze the number of pumps requiring modification or the degree of modification required, so the cost of this modification was not analyzed. For those pumps that can still operate, the cost to pump that water would likely increase due to the additional head required for pumping; this cost was analyzed.

There could be effects to water supply to Irrigon and Umatilla Fish Hatcheries, which receive water from shallow aquifer Ranney wells. The Corps (1994) found that each foot of drawdown reduced the water supply by 10 percent in a study that evaluated reducing the minimum pool to 257 feet, which is 4 feet lower than the proposed measure.

This measure could also affect groundwater because the head would be lower for the irrigation season than under No Action Alternative operations. The 1.5 feet of head difference could lower groundwater levels up to 1.5 feet (while the relationship may be less than one to one, it should not result in groundwater level reductions of more than 1.5 feet).

#### Social Welfare Effects

#### *Irrigation*

This analysis assumes that the currently irrigated lands (approximately 212,225 acres) would remain in production. This level of production would require increased pumping costs. Due to the drawdown, pump efficiencies would change, requiring more energy to pump the same quantity of water to the irrigated lands.

The additional power requirement was estimated based on a sample of pumps. Available pump information and use rates were used to estimate the energy requirement to maintain the operability when the reservoir is lowered the additional 1.5 feet.

The cost of the additional power requirement was valued using power prices for pumping, which were obtained from the power and transmission analyses (see Section 3.8, *Power and Transmission*). A range of pumping rates (minimum and maximum estimates) was used to calculate the initial pumping cost or the pumping cost for the first year of the 50-year period of analysis. The average rate of change from the Power and Transmission (Section 3.8) analysis was used to calculate the annual pumping costs. This rate of change was applied to the initial pumping cost estimate to estimate the additional pumping costs over the 20-year period as shown in Table 3-282. To accommodate a 50-year period of analysis, the forecasted prices were extended to 50 years. The pumping costs beyond the 20-year period were held constant at the year 20 estimate to the end of the 50-year period of analysis.

**Table 3-282. Estimated Power Rate and Additional Pumping Costs for Year 1, and Average 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% |

The annual pumping costs, which represent the additional pumping cost over the No Action Alternative, were discounted over the 50-year period of record using the 2020 Federal planning rate (2.75 percent). The present values are shown in Table 3-283 along with the annual equivalent and the estimated per acre increase. These values represent a decrease in net farm income across the region under MO4. The change in social welfare would be equal to these estimated differences in pumping costs between the MOs across the 50-year period of analysis.

**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 |

***Municipal and Industrial***

The physical effects to M&I were not estimated under the MO4 conditions due to lack of data specific to the pumps. It was assumed that there would be no physical effect to delivering M&I water.

**Regional Economic Effects**

***Irrigation***

This analysis assumes that the currently irrigated lands would remain in production; however, due to changes in pumping efficiencies as a result of the drawdown, increased pumping costs would be required to maintain irrigation needs. This additional power requirement would result in additional annual pumping costs estimated at $260,000 to $277,700 annually for the entire study area (see Appendix N, *Water Supply,* for more information).

It is possible that some of the pumps and wells may need to be modified to continue to operate at the deeper elevation. Due to incomplete data, this was not evaluated for this study. The Corps evaluated construction cost for modification of pumps and wells in 1994; however, that study evaluated reducing the elevation down to 257 feet NGVD29 (260.2 feet NAVD88), which is 4 feet deeper than is proposed in this alternative. Given the uncertainty with indexing and the unknowns as to which pumps would be impacted at the shallower drawdown, this information was not used in this study.

Increased pumping costs would result in lower net farm income across the region, which translates to farm households having less money to spend within the regional economy. IMPLAN was used to estimate the regional effects (employment, labor income, and output) resulting from less money being spent within the study area by farm households. The increased pumping cost was modeled in IMPLAN as a household income change. The lost employment, labor income, and output would result from an increase in pumping costs that is expected to range from $260,000 to $278,000 (annual equivalent, rounded) as described in the Social Welfare Effects section, above. The average annual employment impact was estimated to be a decrease in employment (less than five jobs), labor income ($55,400 to $59,000), and output ($176,000 to $188,000).

***Municipal and Industrial***

The physical effects to M&I water were not estimated under the MO4 conditions due to lack of data specific to the pumps. It was assumed that there would be no physical effect to delivering M&I water.

**Other Social Effects**

Other social effects capture additional effects that are not measured in the social welfare or region economic effects analyses. There are no other social effects expected as a result of the change in pumping costs.

**SUMMARY OF EFFECTS**

In Region B, there are expected to be negligible effects to social welfare and regional economic effects as a result of higher pumping costs. No other social effects are expected in Region B.

As a result of the lowering of the reservoir, MO4 includes an operational measure that could affect water supply from the John Day Reservoir (*the Drawdown to MOP measure*), the water supply to Irrigon and Umatilla Fish Hatcheries, and groundwater. In Region D, the social welfare effects of increased pumping costs compared to the No Action Alternative are estimated to decrease social welfare by between $7.0 million and $7.5 million (present value) over the 50-year period of analysis. This equates to an annual equivalent value over the 50-year period of between $260,000 (rounded) and $278,000 (rounded). These are considered negligible effects.

The regional economic impact of the drawdown under this alternative is expected to be in the form of lower net farm income in the region as a result of the increase in pumping costs. The increased cost is estimated to decrease employment by five jobs, decrease labor income by between $55,400 and $59,000, and decrease total output by between $176,000 and $188,000. Overall, MO4 is expected to result in negligible effects to water supply. There are no other social effects expected as a result of the change in pumping costs.

## 3.13 VISUAL

### 3.13.1 Introduction and Background

The Columbia River Basin landscape is diverse, ranging from rugged forests to arid shrub-steppe landscapes. From east to west, the viewshed transitions from mountain streams and lakes to arid valleys and agricultural lands, culminating with the Columbia River Gorge cutting through the Cascade Range. Visual resources include these landforms, vegetation, water, color, adjacent scenery, and human-made modifications such as the distinct structures associated with each CRS project and the infrastructure associated with their authorized uses. Evaluating the visual qualities of an area, or viewshed, is a process that acknowledges the value that an observer places on a specific feature varies depending on their perspective and judgment. A qualitative visual resource assessment was conducted to assess the baseline visual environment and determine whether alterations associated with the alternatives would alter the visual environment. Accordingly, this section evaluates changes to the viewshed from the MOs based on changes in visual qualities such as color, vegetation, and landforms, and how these changes affect different viewer types.

#### *3.13.1.1 Area of Analysis*

The analysis area includes the visual environment along the river systems associated with the 14 Federal projects. This includes line-of-sight, observable viewshed features associated with the river systems and CRS projects depicted in Figure 1-1. The four regions in the area of analysis are defined in Figure 3-1.

### 3.13.2 Affected Environment

The area of effect, or viewshed, is a portion of the analysis area where an object or visual intrusion can be seen. It includes all surrounding points that are in the line of sight and excludes points beyond the horizon or obstructed by terrain or other existing features. The viewshed includes natural and human-made features. Areas that are seldom seen were not included in the analysis based on the scale of this EIS.

Project infrastructure is a substantial part of the viewshed and includes concrete dams, powerhouse and spillway structures, access roads, transmission structures, warning and navigational buoys, visitor and information centers, and water-passage features for fish migration and water vessels. Intermittent maintenance and project-improvement activities are considered to be a part of the viewshed similar to traffic being considered part of the viewshed within a highway right-of-way. Other infrastructure contributing to the visual environment includes parks, facilities, and access points that are designed for recreational use or for utilities such as irrigation or transporting agricultural resources. These may also change periodically with minimal impact to the overall viewshed. Within these river and reservoir systems, the natural landscapes constitute much of the viewshed. The topography varies as one travels down the watershed, fashioning the characteristic landscapes. Steep mountains with their forested slopes and narrow canyon walls are often accompanied by swift flowing rivers and heavy spring flows. These landscapes transition into rolling hills and gentle streams with diverse vegetation or give way to basalt plains. Anthropogenic features are typically concentrated in specific locations. Rural settings are characterized with sparsely populated homes and extensive agricultural fields, which wind their way through open valleys. Urban areas include numerous small and mid-sized towns where sights and sounds are dominated by human development and activity. The reservoir systems include major alterations to the natural landscapes for the enormous hydropower infrastructures and for developed recreational facilities. The presence or absence of water is an important factor in determining visual quality as it adds to or subtracts from the attractiveness of an area. Throughout the Columbia River Basin, viewsheds are also important to tribal members engaging in traditional cultural practices or visiting traditional cultural sites and could be affected by infrastructure (e.g., fish hatcheries, parks, levees, fencing, signage, access roads).

The geographic regions described above and depicted in Figure 1-1 have varying viewshed qualities and viewer accessibility:

- Region A has river and reservoir systems that cut through rocky uplands and steep mountains associated with the Kootenai National Forest near Libby, Montana, and the Flathead National Forest near Hungry Horse, Montana, to semi-forested and arid valley terrain downriver of these reservoirs. This region is mostly rural with some small- and moderate-size communities.
- Region B is dominated by a mix of rugged basalt, arid, and rocky landscapes dotted with forests and hills, agricultural features, small- and moderate-sized communities, and some industrial facilities. Lake Roosevelt is a notable feature created by impoundment with the construction of Grand Coulee.
- Region C has changing landscapes from the more remote Clearwater National Forest around Dworshak Reservoir in the east to rolling hills and basalt plains in the west. Vegetation along the river is characterized as shrub steppe with nearby agricultural plots. In addition to agriculture, other associated land uses include recreation, residential, and shipping ports, with greater concentrations near the moderate-sized communities.
- Region D has arid, basalt plain landscapes in the east with rural viewsheds dotted with agricultural features and small- to moderate-sized communities. To the west, this landscape changes with the scenic Columbia River Gorge, which is the portion that runs between the Gifford Pinchot National Forest on the Washington side and Mount Hood National Forest on the Oregon side. Numerous state and local parks are located along the riverfront or have views of the river, which take advantage of the high-quality visual settings of surrounding natural landscapes.

### 3.13.3 Environmental Consequences

The effects to visual resources are analyzed by systematically measuring the degree of change created by a proposed alternative. This is done by comparing the basic elements of line, form, color, and texture within the existing viewshed to those introduced by the alternative. Factors that need to be considered are distance, viewing times, relative size and scale, season of use and light conditions, recovery time, spatial relationships, as well as noise and motion.

Impacts to the viewer are determined by analytically measuring the sensitivity of differing viewer groups. Sensitivity attaches relative importance values to differing landscapes based on perceived user expectations and activities. Tribal members and recreationalists are among the most sensitive of all viewing groups. Additionally, viewers are divided into two types: static and non-static. Static viewers include residents, reservoir and project employees, recreation management agencies, tribal members, and recreation visitors to an area. Non-static viewers are mainly defined as people traveling through area or along access roads and may have limited views of the viewshed. The sensitivity of the different types of viewers varies based on their perceptions of the area and the importance they place on the landscape, or how they interpret visual quality. Casual observers are typically engaged in other activities so they may not notice landscape changes. Sensitive viewers actively view the landscape and have a deeper connection to the visual environment. Recreationalists and tribal members have the highest sensitivity level. Even small visual changes may affect the experience for tribal members engaging in cultural activities or practices.

There are no anticipated visual effects in Canada as a result of the MOs in this EIS.

#### *3.13.3.1 No Action Alternative*

Under the No Action Alternative, the rivers and reservoirs in the analysis area would experience seasonal fluctuations. In many cases, such as the run-of-river projects, water surface elevations remain within a couple of feet throughout the year, but in some instances, the changes are much larger with reservoir elevation changes of 50 feet or more. With this large potential for reservoir elevation changes, natural-appearing landscapes would vary dramatically over the course of a year, affecting the visual quality. The degree of color contrast varies based on the width of the exposed shoreline during drawdown and the surrounding topography. The stark differences in form, color, and texture create a band of visual contrast separating vegetation communities and the surface of the reservoir. Because drawdowns normally occur gradually over the course of the spring and summer seasons, with lower elevations occurring after the height of the recreation season, the most severe effects would likely not be noticed by sensitive viewers. Residents and repeat visitors to the areas have become accustomed to these seasonal changes and are not substantially affected by the changes to the visual quality. However, tribal members could be affected by seasonal changes in reservoir levels while engaging in cultural activities or practices. Other localized and temporary impacts would result from pollution, algae blooms, plant or animal debris, water color, and turbidity.

Visual effects would vary throughout the year with changes in reservoir elevation, most notably at the storage projects. These changes depend on natural climate conditions and water management actions. To characterize the median annual range difference, two values are used: the uppermost median value and the lowermost median value for typical water years (the middle 60 percent of water years), each of which typically occur at a given time of year.
For storage reservoirs, the uppermost is usually in the summer, and the lowermost is usually in

the late winter or spring. Reservoir elevations can vary dramatically from year to year, so the area of exposed shoreline and smaller reservoir varies accordingly, ranging from moderate during dry and normal years to high during years with large water supply forecast and inflows. Therefore, the visual quality would experience the same annual variability.

**TRIBAL INTERESTS**

To the extent operational or structural measures affect the viewshed, this can have unique impacts on spiritual practices for tribes. Per the Tribal Perspectives document submitted by the Confederated Colville Tribes, these viewsheds are important for vision quests.

"Vision quests are used by tribal members to obtain a guardian spirit, power, or medicine. These sites are often marked by cairns (Figure 4), although many times they are also left unmarked (Cline 1938, Ray 1942). Integrity of setting is very important for vision quest sites. While vision quest sites usually sit great distances from the Columbia River or other rivers, these rivers often lie in the viewsheds of these sites. The appearance of the river or sounds coming from the river can affect the setting of a vision quest site. For example, the setting during the drawdown behind Grand Coulee Dam differs greatly from that during full pool. This affects the experience for the individual on a vision quest." (Appendix P, *Tribal Perspectives*)

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

**Operational Measures**

At Libby Dam (Lake Koocanusa), the median annual reservoir elevation ranges from a minimum of 2,384.2 feet in the spring to a maximum of 2,453.3 feet in the summer for an annual difference of 69.1 feet. At Hungry Horse Reservoir, the median annual reservoir elevation ranges from a minimum of 3,521.7 feet in the spring to a maximum of 3,559.7 feet in the summer for an annual difference of 38.0 feet. At Albeni Falls (Lake Pend Oreille) the median annual reservoir elevation ranges from a minimum of 2,051.3 feet in the winter to a maximum of 2,062.3 feet in the summer for an annual difference of 11.0 feet. See Section 3.2.4.3 for more detailed information on reservoir fluctuation. Viewership during reservoir elevation changes would be limited to local populations and low visitation times. There would be a decrease in visual quality during low reservoir elevations. Using the median annual fluctuation, the degree of change between water, exposed shoreline, and vegetation communities, the impacts to visual quality would be minor with similar impacts to the casual observer. Reservoir elevations would vary from year to year, but the level of effect would not substantially change. More sensitive viewers may experience a moderate effect during years with lower reservoir levels. Sensitive viewers during reservoir elevation decreases would include tribal members and recreationalists. Therefore, these viewer groups would experience a moderate effect.

**Structural Measures**

Planned structural changes include an extensive modification of Hungry Horse Dam facilities. Although these are substantial efforts, the introduced change in visual quality would be minimal because the alterations mirror the existing structures, retaining the basic design elements such of line, form, color, and texture of the existing facilities. Construction activities would draw the attention of casual observers within the immediate area, but the effect would be minimal and diminish over a 10-year period as the changes are completed. The effect to all viewers along the rivers and reservoirs in the analysis area would not substantially change and therefore would be minor.

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

**Operational Measures**

Seasonal fluctuations and drawdown of Lake Roosevelt (Grand Coulee Dam) would affect the visual quality of the landscape. Lower reservoir levels would expose more of the shoreline, increasing the contrast between the water surface, shoreline, and vegetation communities. Subsurface features would be exposed. At Lake Roosevelt, the median annual reservoir elevation ranges from a minimum of 1,245.6 feet in the spring to a maximum of 1289.5 feet in the summer for an annual difference of 43.9 feet (Reclamation 2019c; Section 3.2.2.3). Reservoir elevation changes vary dramatically from year to year so the area of exposed shoreline and smaller reservoir varies accordingly, ranging from moderate during dry and normal years to high during years with extreme fluctuation in reservoir level. The expansion of the shoreline during periods of low reservoir levels would result in a minor degree of change with minimal effect to visual quality. During the winter months, changes in atmospheric conditions and snow cover would reduce the overall color contrast, which would further mitigate some of these effects. Effects to the casual observer and some sensitive viewers would be minor because the higher visitation periods at Lake Roosevelt correspond with higher reservoir elevations.

**Structural Measures**

Planned structural changes at Grand Coulee include the modernization of the third power house. Effects to visual resources would be limited to construction activities that occur outside of the existing buildings and would include the visual intrusions created by the placement of the temporary buildings and the development of staging area. The overall visual quality would not be substantially impacted because the elements of line, form, and color produced by the dam would not change over the long term. The temporary buildings and staging areas that would be visible vary in locations within 5 miles of the dam. During the life of the project, the increase in activity would be seen and may draw the attention of the casual observer. Because the dam facilities are important to local communities, this is not likely to conflict with the viewer expectations and impacts to all viewer groups would be minor.

### REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

#### Operational Measures

Visual effects would occur annually at Dworshak. These changes in reservoir elevation would be dependent on natural climate conditions and water management actions. At Dworshak Reservoir, the median annual reservoir elevation ranges from a minimum of 1,518.8 feet in the spring to a maximum of 1,600.0 feet in the summer for an annual difference of 81.3 feet (Section 3.2.4.3).

Timing for operation of spill volume at the run-of-river projects on the lower Snake River would be weather dependent and in association with juvenile fish passage program objectives. The degree of change could vary sharply from year to year based on the actual decrease in the reservoir levels and therefore would range from minor to moderate depending on environmental conditions. Viewer effects during Dworshak Reservoir elevation decreases would be experienced by casual observers and sensitive viewing groups. Because the reservoir would be drawn down in the summer and early fall, which coincides with the timeframe for peak recreational use, the effect to visual sensitivity would be higher for recreationalists. Therefore, while the impacts would be minor to local populations who are accustomed to the seasonal fluctuations, the impacts to more sensitive viewers would be moderate.

#### Structural Measures

Visual effects may be observable from structural changes to projects and infrastructure for maintenance, which may draw the attention of the casual observer, resulting in a moderate degree of change. However, these types of activities would be short term during construction or maintenance. Structural modifications would also have negligible effects on visual quality, but they would be long term. Impacts to the sensitive viewers in the vicinity of those construction activities would be minor.

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

#### Operational Measures

Visual quality effects would vary throughout the year with changes in reservoir elevation at the projects located within Region D. These changes in reservoir elevation would depend on natural climate conditions and water management actions. Columbia River dams vary river and reservoir elevation by a few feet. Timing of visual effects through operational changes in spill volume would be weather dependent and in association with juvenile fish passage program objectives. With minimal change in elevation, the effect on visual quality, as well as effect on casual observers and sensitive viewers, would be minor.

**Structural Measures**

Visual effects may be observable from structural changes to projects and infrastructure for maintenance projects and ongoing fish migration improvements (Section 2.3.2.1.), which may draw the attention of the casual observer, resulting in a moderate degree of change. However, these types of activities would be short term during construction or maintenance. Structural modifications would also have negligible effects on visual quality, but they would be long term. Effects to the sensitive viewers in the vicinity of those construction activities would be minor.

**SUMMARY OF EFFECTS**

Under the No Action Alternative, short-term impacts would continue to result in both minor and moderate visual quality impacts associated with seasonal changes in reservoir elevations and maintenance activities. The impacts to the casual observer would be minimal; however, sensitive viewers may continue to experience moderate impacts. Structural changes would occur with a minimal impact to visual quality, and with minor impacts to all viewer groups.

### *3.13.3.2 Multiple Objective Alternative 1*

Under this alternative, changes to reservoir elevation would occur due to operational changes at storage projects. Lower elevations would have similar impacts to those described for the No Action. However, the degree of change between exposed shoreline, water, and vegetation communities would differ based on the variations in the timing, duration, and the rate of the drawdowns. Seasonal changes in reservoir elevation include periods of higher reservoir elevations, which would benefit visual quality by reducing the exposed shoreline and creating a more natural-appearing landscape. In addition to changes in reservoir elevations, river flows and stages in the region would change relative to the No Action Alternative (see Table 2-3 and Section 2.3.3.1). Increased flows may create localized water turbidity which may alter water color and clarity. Scheduling of operational changes in management of reservoir elevation at Hungry Horse, Libby, Grand Coulee, Albeni Falls, Dworshak, and John Day Dams may affect the seasonal timing and duration of changes to visual quality and would have a minor effect on sensitive viewers and a negligible effect on the casual observer.

For Regions A and B, visual effects from structural changes to projects and infrastructure for construction and maintenance (see Table 2-3 and Section 2.3.3.1) would be the same as described for the No Action Alternative. Structural changes for MO1 include specific modifications to lower Columbia and lower Snake River projects for fish passage. These types of activities would be short term during construction or maintenance and would have a minor, short-term visual effect on casual observers in the immediate vicinity of the project. Therefore, Regions A and B are not discussed further under MO1.

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

**Operational Measures**

Scheduling operational changes in the management of reservoir elevation at Dworshak Dam and the lower Snake River projects may affect the seasonal timing and duration of changes to visual quality and may have a minor effect on all viewer groups in the immediate vicinity.

**Structural Measures**

Modification of project passage facilities such as upgrades to spillway weirs, modifications to fish ladders, and installation of passage routes at the lower Snake River projects would create a low degree of change by retaining the existing line, form, color, and texture. The impacts related to these activities would be minor and short term. While new structures could result in moderate changes to the existing viewshed, visual quality impacts would generally be minor with a similar level of effect to the casual observer in the vicinity of those construction activities.

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

**Operational Measures**

Operational changes at John Day Reservoir would result in minimal change to reservoir elevation over a few months. The casual observer near the project would likely not notice the change compared to changes in reservoir elevation that occur annually as described under the No Action Alternative.

**Structural Measures**

Modification of project passage facilities such as upgrades to spillway weirs, modifications to fish ladders, and installation of passage routes at the lower Columbia River projects would result in visual impacts similar to those described for Region C.

**SUMMARY OF EFFECTS**

Overall, the operational and structural measures under MO1 would have a similar effect on the visual quality and to all viewer groups as under the No Action Alternative. There may be a moderate effect to visual quality from new fish passage structures, with only a minor effect to modifications fish passage structures, modifications to fish ladders, and changes to spillway weirs at the lower Columbia River projects in Region D and the lower Snake River projects in Region C, but overall, the effects from MO1 would be minor.

### *3.13.3.3 Multiple Objective Alternative 2*

Operational change effects to visual resources are also similar to the No Action Alternative with additional focus on increasing hydropower generation by limiting spill at the lower Columbia and lower Snake River projects and allowing flexibility in reservoir elevations as described in Section 2.3.4.1. These changes are not likely to add additional effects to the viewshed from what is previously described for the No Action Alternative. Similar to MO1, MO2 would include specific modifications to the lower Columbia and lower Snake River projects for fish passage. For Regions A and B, structural changes to projects and infrastructure may be necessary for maintenance and are described under the No Action Alternative. These types of activities would be short term during construction or maintenance activities and would be a minor visual effect to viewers in the immediate vicinity of the project; therefore, Regions A and B are not discussed further under MO2.

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

**Operational Measures**

Scheduling operational changes in the management of reservoir range operations at the four lower Snake River projects may have a minor effect on sensitive viewers. The casual observer would likely experience effects, but to a lesser extent, because changes in reservoir operations occur annually as described under the No Action Alternative.

**Structural Measures**

Modification of project passage facilities such as upgrades to spillway weirs, modifications to fish ladders, and installation of passage routes at the lower Snake River projects would create a low degree of change by retaining the existing line, form, color, and texture. The impacts related to these activities would be minor and short term. While new structures could result in moderate changes to the existing viewshed, visual quality effects would generally be minor with a similar level of effect to the casual observer in the vicinity of those construction activities.

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

**Operational Measures**

Operational changes at John Day Reservoir would result in minimal change to pool elevation. The casual observer would not likely notice the change compared to changes in reservoir elevation that occur annually as described under the No Action Alternative.

**Structural Measures**

Modification of project passage facilities such as upgrades to spillway weirs, modifications to fish ladders, and installation of passage routes at the lower Columbia River projects would result in visual impacts similar to those described for Region C.

**SUMMARY OF EFFECTS**

Overall, the operational and structural measures under MO2 would have a similar effect on visual quality and to viewers as under the No Action Alternative. There may be a minor effect from new fish passage structures, modifications to fish ladders, and changes to spillway weirs at the lower Columbia River projects in Region D and lower Snake River projects in Region C, but overall, the effects from MO2 would be minor.

### *3.13.3.4 Multiple Objective Alternative 3*

Effects from operational changes for MO3 are similar to those described under the No Action Alternative with regard to changes in management of reservoir elevation for storage projects, and changes that would increase spill as described in Section 2.3.5.1. Substantial structural changes would occur at the four lower Snake River projects to return this portion of the Snake River to a free-flowing river. This would result in a high degree of change within the existing viewshed from a series of impounded reservoirs changing to free-flowing riverine conditions. Structural changes also include specific modifications to lower Columbia River projects for fish passage. For Regions A and B, structural changes to projects and infrastructure may be necessary for maintenance and are described under the No Action Alternative. These types of activities would be short term during construction or maintenance activities and would result in a minor visual effect to viewers in the immediate vicinity of the project; therefore, Regions A and B are not discussed further for MO3.

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

**Operational Measures**

Visual impacts from management of reservoir elevation at Dworshak would be no different than those described for the No Action Alternative.

**Structural Measures**

Removal of earthen embankments and some associated project infrastructure at the four lower Snake River projects would noticeably alter the viewshed at the four lower Snake River projects, and downriver from each project to the confluence of the Snake River with the Columbia River. The loss of the wide reservoirs would permanently expose portions of shoreline or reservoir bottom leading to temporary dust effects, erosion susceptibility, and rendering previous shoreline recreational facilities obsolete. Over time, the bare shoreline may revegetate and subsequently decrease the potential for erosion (Corps 2002b). These changes would alter that line, form, color, and texture within the existing viewshed and would result in a high degree of change. There would be a major visual quality impact that would diminish as the shoreline revegetates and blends into the surrounding landscape. With breaching of the lower Snake River projects, increases in road and rail transportation and the possible need for new infrastructure (see Section 3.10) to compensate for a reduction in river transportation would increase the level of change and could affect the visual quality.

The impacts to viewers would vary dramatically based on viewer expectations, preference, and connection to the area. The degree of this impact is directly related to their sensitivity. The loss of earthen embankments and some project infrastructure may increase visual quality of the area for some sensitive viewers along the lower Snake River and counterbalance the loss of the lake-like viewshed. These viewers could be enriched by the return of the lower Snake River to a free-flowing riverine ecosystem. The cultural and spiritual attributes of a free-flowing river would be a positive outcome for tribes and others who value these attributes. The loss of reservoir attributes would likely have an adverse effect on the quality of the landscape for other viewer groups, such as residents and occupational viewers who associate the reservoirs with the identity of the area, as in the Lewiston area where loss of port capability could also occur (Corps 2002b).

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

### Operational Measures

Visual impacts from management of increased spring spill would be negligible compared to those described for the No Action Alternative.

### Structural Measures

Modification of project passage facilities such as upgrades to spillway weirs, modifications to fish ladders, and installation of passage routes would create a low degree of change by retaining the existing line, form, color, and texture. The effects related to these activities would be minor and short term. While new structures could result in moderate changes to the existing viewshed, visual quality impacts would generally be minor with a similar level of effect on the casual observer in the vicinity of those construction activities.

## SUMMARY OF EFFECTS

Overall, the operational measures under MO3 would have a similar effect on the viewshed and to viewers as under the No Action Alternative, and the overall effect would be minor.

For the structural measures, there would be major alterations to the viewshed associated with the dam breaching at the four lower Snake River projects and the associated changes to the landscape in Region C. Viewers would see substantial changes to the landscape in the vicinity of the lower Snake River projects with the loss of earthen embankments and some associated project infrastructure. There would be a loss of lake-like characteristics in the lower Snake River with the addition of the free-flowing river characteristics. Overall, the visual effect of dam breaching would be major. Depending on the viewer's perspective, this change could be beneficial or negative. All other structural measures would have a minor overall impact.

#### *3.13.3.5 Multiple Objective Alternative 4*

Changes to reservoir elevation from operational changes at storage projects would affect the viewshed and viewers in much the same manner as the No Action Alternative would. Operational measures in MO4, notably the *McNary Flow Target* measure, may have a minor, short-term effect on visual quality during the summer during drier-than-normal years resulting in Lake Koocanusa, Hungry Horse Reservoir, Lake Pend Oreille, and Lake Roosevelt having decreasing water levels. These drawdowns would result in a moderate degree of change to the existing viewshed, resulting in a moderate impact to visual quality. This would occur when recreational use is high, resulting in a greater exposure of sensitive viewers to the associated changes in visual qualities (see Figures 3-75, 3-79, 3-83, and 3-89). Structural changes for MO4 include structural changes to projects and infrastructure necessary for maintenance and specific modifications to lower Columbia and lower Snake River projects for fish passage. The visual impacts would be short term during construction or maintenance activities and would result in a minor visual effect on viewers in the immediate vicinity of the project.

**REGIONS A AND B – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS; GRAND COULEE AND CHIEF JOSEPH DAMS**

**Operational Measures**

The *McNary Flow Target* measure drafts the storage projects in Region A and B for fish flows in the lower basin. These drawdowns would result in a moderate degree of change from the existing viewshed, resulting in a short-term moderate effect on visual quality during the late summer during drier-than-normal years. This would occur when recreational use is high, resulting in a greater exposure of sensitive viewers to the associated changes in visual qualities (see Figures 3-75, 3-79, and 3-83). For this reason, there would be moderate effects on sensitive viewers.

**Structural Measures**

Modification of project passage facilities such as upgrades to spillway weirs, modifications to fish ladders, and installation of passage routes would create a low degree of change by retaining the existing line, form, color, and texture. The impacts related to these activities would be minor and short term. While new structures could result in moderate changes to the existing viewshed, visual quality impacts would generally be minor with a similar level of effect on the casual observer in the vicinity of those construction activities.

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

**Operational Measures**

Reservoir drawdown to minimum operating pool would result in lower Snake River projects operating at lower elevations during a portion of the year (see Section 2.3.6.1). The casual observer would be unlikely to notice the change compared to changes in elevation that occur annually as described under the No Action Alternative.

**Structural Measures**

Structural changes to projects and infrastructure maintenance would result in visual impacts similar to those described for Region A.

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

**Operational Measures**

Reservoir drawdown to minimum operating pool would result in lower Columbia River projects operating at lower elevations during a portion of the year (see Section 2.3.6.1). The casual observer would be unlikely to notice the change compared to changes in elevation that occur annually as described under the No Action Alternative.

**Structural Measures**

Structural changes to projects and infrastructure maintenance would result in visual impacts similar to those described for Region A.

**SUMMARY OF EFFECTS**

Overall, the operational measures under MO4 would have an increased effect on visual quality and all viewer groups compared to the No Action Alternative. During summer months, there may be a major effect on the viewshed from lower reservoir levels at Lake Koocanusa, Hungry Horse Reservoir, Lake Pend Oreille, and Lake Roosevelt with corresponding effects experienced by all viewer groups. There would be a moderate effect on visual quality from new fish passage structures and a minor effect from modifications to fish ladders and changes to spillway weirs at the lower Columbia River projects in Region D and lower Snake River projects in Region C.

## 3.14 NOISE

### 3.14.1 Introduction and Background

Noise is unwanted sound that disrupts normal activities or diminishes the quality of the environment for humans and other sensitive receptors. Depending on the intensity and level of exposure, excessive noise could lead to a range of effects: disrupted sleeping, difficulty communicating, changes in behavior, increases in stress levels, and physical injury (EPA 1978). At sound levels below those that cause physiological effects noise can reduce the aesthetic quality of the environment, especially in natural settings enjoyed by recreationalists, and may affect resource integrity for tribal members engaging in cultural activities or practices. This section evaluates potential noise effects to receptors such as humans, fish, and wildlife.

#### *3.14.1.1 Area of Analysis*

The analysis area for sound effects centers on each CRS dam and reservoir project site and follows a radius extending out to 3 miles. At this distance, sound levels normally diminish due to attenuation—by 50 decibels on the A-weighted scale (dBA)—rendering almost all sounds from project sites indistinguishable from background or ambient conditions. Effects outside this analysis area may occur with substantial changes in transportation methods. For example, if barge traffic decreases, truck and train transport may increase, which would increase noise levels along certain roads and rail routes.

### 3.14.2 Affected Environment

Noise traveling through air is usually expressed in decibels on the A-weighted scale, which is weighted to account for how humans hear sound. Table 3-284 provides typical noise levels in dBA from common sources. Noise exposure depends on the amount of time an individual spends near the source and distance from the source. To account for fluctuating sound levels, statistical descriptors have been developed for environmental noise. Exceedance levels (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the time during a specified period. Thus, $L_{10}$ refers to a particular sound level that is exceeded 10 percent of the time.

**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 |

Source: Cavanaugh and Tocci (1998); EPA (1978); Federal Highway Administration (2006); Washington Department of Transportation (2018)

The Noise Control Act of 1972 (42 USC § 4901 et seq.), as amended, sets forth a broad goal of protecting all people from noise that jeopardizes their health or welfare. The Act further states that Federal agencies are authorized and directed, to the fullest extent consistent with their authority under Federal laws administered by them, to carry out the programs within their control in such a manner as to further this policy. Some states regulate noise by specifying allowable noise levels; although Federal agencies are not required to follow these state regulations, they provide useful benchmarks for analysis. The Washington Administrative Code (WAC 173-60) and the Oregon Administrative Rules (OAR 340-035) specify noise limits according to the type of property where the noise would be heard (the "receiving property").[1] Hydroelectric dams are classified as industrial sources for purposes of establishing allowable noise levels at the receiving property. Washington limits maximum-permissible-average-noise levels from industrial sources to 60 dBA (daytime) and 50 dBA (night) at a residential property or recreation facility such as a park or campground (WAC 173-60); louder sound levels are allowed for short durations depending on the dBA level. Oregon allows an $L_{50}$ noise level of 55 dBA in daytime and 50 dBA at night and $L_{10}$ of 60/55dBA day/night (OAR 340-035). Under the Washington and Oregon regulations, daytime construction noises are usually exempt during the day.

Ambient noise levels vary widely among the project sites depending on the surrounding land use and topography. Table 3-284 provides typical sound levels found in different settings.

More rural CRS project sites such as Hungry Horse, Libby, Dworshak, Lower Granite, Little Goose, Lower Monumental, and John Day likely have ambient sound levels within the analysis area in the range of 35 to 40 dBA, especially at night, which are typical of rural settings (EPA 1978). In each of these areas, the project itself may be a major local sound source through spillway noise, operation of the locks, substations and transformers, and maintenance operations. Although sound levels can be very high near operating turbines inside the powerhouse, this sound is usually substantially attenuated by the concrete superstructure of the project. Other major sound sources in these areas are nearby roads and railroads, agricultural or timber harvesting activities, recreational or commercial boat traffic, and wind.

Several CRS project sites such as Albeni Falls, Grand Coulee, Chief Joseph, McNary, The Dalles, and Bonneville are near towns or populated areas. Ambient sound levels near these projects in closer proximity to more populated areas are likely higher than near the more rural projects described above because of increased vehicular traffic, commercial activities, and residential property maintenance activities, in addition to project operations.

The distance to the nearest people who may experience noise effects at either a residential or recreational site ranges from 2.41 miles at Lower Monumental Dam to 0.24 mile at Albeni Falls Dam. The decrease in sound levels due to attenuation in relation to the nearest residence or recreational site at all the project sites averages approximately 36.5 dBA. People who are near the site for shorter periods, such as workers, fisherman and hunters, and tribal members 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.

could experience higher sound levels. Wildlife also could be much closer to any of the project sites, and therefore could experience higher sound levels. Underwater sound is also part of the ambient environment for fish and for wildlife such as diving birds and semi-aquatic animals such as beaver and muskrat. Primary contributors within the project area include operation of the spillways and locks and some maintenance at the project sites, as well as operation of boats, barges, grain terminals, and other shore-based industrial activities.

## 3.14.3 Environmental Consequences

### *3.14.3.1 No Action Alternative*

Under the No Action Alternative, all of the project sites in Regions A through D would continue existing operations and maintenance and associated sound levels. There are no anticipated noise effects in Canada as a result of the alternatives in this EIS.

**OPERATIONAL MEASURES**

Operation of the spillways, navigation locks, fishways, transformers, and turbines would continue to support flood risk management, irrigation, water supply, navigation, power production, recreation, and fish passage. The amount of water released through the spillway and the associated noise level at each project varies during the year, with generally higher sound levels during periods of high discharge and lowest during periods of low river discharge. At times, there may be no spillway-associated noise. Maximum spillway noise varies from year to year, depending on the level of spring runoff. Other sound sources such as transformers and turbines have sound levels that remain relatively constant during the year.

**STRUCTURAL MEASURES**

Periodic routine, non-routine, and unscheduled maintenance would continue to occur, and several previously planned structural modifications would occur as described in Section 2.3.2. Maintenance activities and previously planned structural changes could involve trucks, cranes, and pneumatic tools, which could temporarily increase ambient sound levels while the maintenance activity or modification is implemented. These actions could combine to create intermittent and temporary sound levels of over 90 dBA. The sites closest to people, such as Bonneville, Chief Joseph, Grand Coulee, McNary, and Albeni Falls Dams, could experience noise-level decreases of 28 to 33 dBA due to distance; these project sites could thus expose those individuals to temporary peak sound levels between 55 and 65 dBA. All these sites, however, are in relatively populated areas with likely daytime ambient sound levels between 50 and 60 dBA, thus all but the loudest peak noises would be undetectable by the nearest residents and peak levels may be noticeable but would not likely cause annoyance. Sounds from these activities are currently part of the overall ambient soundscape in each project site vicinity. Wildlife closer to project sites may exhibit some startle reflexes or behavioral changes due to sounds from normal activities performed under the No Action Alternative. Underwater sound levels would continue to be similar to current levels.

**SUMMARY OF EFFECTS**

Noise associated with project operations would continue to occur, as would noise associated with periodic maintenance and planned structural modifications. Underwater sound levels would continue to be similar to current levels.

### *3.14.3.2 Multiple Objective Alternative 1*

In addition to the operations and maintenance described for the No Action Alternative, MO1 would include changes to the spill regime at a number of projects, and structural modifications at all of the lower Snake River and lower Columbia River projects.

**OPERATIONAL MEASURES**

The proposed operational changes may alter the timing of peak flows, but would not likely result in flow over spillways, through turbines, or fish passageways greater than existing peak flows experienced during annual periods of heavy runoff. Therefore, proposed operational measures would not change the potential magnitude of sound levels in the vicinity of any of the project sites for any region compared to the No Action Alternative, but could cause minor changes in the seasonal timing or duration of high-flow and high-spillway noise levels at any project.

**STRUCTURAL MEASURES**

No structural measures are proposed for the projects in Regions A or B other than maintenance actions as described in the No Action Alternative and the effects would not differ from those of the No Action Alternative.

The proposed modifications to the lower Snake River and lower Columbia River projects in Regions C and D in MO1 would require temporary use of standard construction tools and equipment. This equipment could combine to produce peak sound levels of 90 dBA or more (at 50 feet) for short periods; therefore, peak sound levels experienced by nearby people could be approximately 65 dBA during the day. This may be noticeable, but would be temporary and would not be likely to cause annoyance to people in nearby residences or recreation areas. Wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while the structural modifications are performed. Some structural modifications could cause temporary increases in underwater sound levels, but these would likely be of shorter duration and much lower levels than those associated with pile driving, and depending on the location and timing of the modification, could be undetectable above the ambient operational project environment. The proposed structural measures would generally use similar equipment to some of the normal maintenance activities as described in the No Action Alternative.

**SUMMARY OF EFFECTS**

Overall, there would be a negligible to minor effect to noise levels from operational measures. The effect of the proposed MO1 structural measures on ambient sound levels at the lower Snake River projects in Region C and lower Columbia River projects in Region D would be similar to the No Action Alternative and would be a minor effect.

### *3.14.3.3 Multiple Objective Alternative 2*

In addition to the operations and maintenance actions described for the No Action Alternative, MO2 would include changes to the spill regime at a number of projects, and structural modifications at all of the lower Snake River and lower Columbia River projects.

**OPERATIONAL MEASURES**

The proposed operational changes may alter the timing of peak flows, but would not likely result in flow over spillways, through turbines, or fish passageways greater than existing peak flows experienced during annual periods of heavy runoff. Therefore, proposed operational measures would not change the potential magnitude of sound levels in the vicinity of any of the project sites for any region compared to the No Action Alternative, but could cause minor changes in the seasonal timing or duration of high-flow and high-spillway noise levels at any project.

**STRUCTURAL MEASURES**

No structural measures are proposed for the projects in Regions A or B under MO2 other than maintenance actions as described in the No Action Alternative and the impacts would not differ from those of the No Action Alternative.

The proposed modifications to the lower Snake River and lower Columbia River projects in Regions C and D in MO2 would require temporary use of standard construction tools and equipment. This equipment could combine to produce peak sound levels of 90 dBA or more (at 50 feet) for short periods; therefore, peak sound levels experienced by nearby people could be approximately 65 dBA during the day. This noise level may be noticeable, but would be temporary and would not be likely to cause annoyance to people in nearby residences or recreation areas. Wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while the structural modifications are performed. Some structural modifications could cause temporary increases in underwater sound levels, but these would likely be of shorter duration and much lower levels than those associated with pile driving, and depending on the location and timing of the modification, could be undetectable above the ambient operational project environment. The proposed structural measures would generally use similar equipment to some of the normal maintenance activities as described in the No Action Alternative.

**SUMMARY OF EFFECTS**

Overall, there would be a negligible to minor effect to noise levels from structural and operational measures under MO2.

### *3.14.3.4 Multiple Objective Alternative 3*

In addition to the operations and maintenance described for the No Action Alternative, MO3 would include changes to the spill regime at a number of projects, structural modifications at all of the lower Columbia River projects, and breaching of the four lower Snake River projects.

**OPERATIONAL MEASURES**

The proposed operational changes under MO3 at sites other than the four lower Snake River projects may alter the timing of peak flows, but would not likely result in flow over spillways, through turbines, or through fish passageways greater than existing peak flows experienced during annual periods of heavy runoff. Therefore, proposed operational measures at all sites other than the four lower Snake River projects would not change the potential magnitude of sound levels in the vicinity of any of the project sites compared to the No Action Alternative, but could cause minor changes in the seasonal timing or duration of high-flow and high-spillway noise levels.

Breaching of the four lower Snake River projects in Region C would reduce the ambient sound levels at the project sites to lower levels than the No Action Alternative because operations or maintenance would cease at those project sites. Breaching of the lower Snake River projects would restore the free-flowing riverine soundscape along the Snake River between the Columbia River and Lewiston, Idaho.

Because breaching of the lower Snake River projects would eliminate barge traffic, MO3 could increase noise levels associated with train and truck traffic in parts of the lower Columbia River Basin. It may also result in relocating barge-loading facilities, with associated increases in sound levels, to locations downstream on the Columbia River. Concurrently, eliminating barge traffic and barge-loading facilities combined with a likely decrease in recreational boating would further decrease the average sound levels both at and within the vicinity of the four lower Snake River projects.

**STRUCTURAL MEASURES**

No structural modifications are proposed at projects in Regions A or B, or at Dworshak in Region C other than general maintenance actions as described under the No Action Alternative. MO3 structural modifications proposed at the lower Columbia River projects in Region D would require temporary use of standard construction tools and equipment. This equipment could combine to produce peak sound levels of 90 dBA or more (at 50 feet) for short periods; therefore, peak sound levels experienced by nearby people could be approximately 65 dBA during the day. This noise level may be noticeable, but would be temporary and would not be likely to cause annoyance to people in nearby residences or recreation areas. Wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while the structural modifications are performed. Some structural modifications could cause temporary increases in underwater sound levels, but these would likely be of shorter duration and much lower levels than those associated with pile driving, and depending on the location and timing of the modification, could be undetectable above the ambient operational project environment. The proposed structural measures would generally use similar equipment to some of the normal maintenance activities as described in the No Action Alternative.

MO3 calls for breaching of earthen embankments and other major structural changes to the four lower Snake River projects in Region C, which would require more construction equipment operating for long periods (at least during daylight hours for several months); this could result in average daytime sound levels over 95 dBA at the construction site, with peak sound levels over 100 dBA, especially if the breaching requires installing sheet piles. Little Goose and Lower Monumental are relatively isolated—they lack residences for at least 1.76 miles. Thus, people near these two sites would likely hear only the loudest peak sounds. There is one residence approximately 0.6 mile from Lower Granite, but otherwise the project vicinity is sparsely populated. The one residence is separated topographically from the project by a ridge, so sound levels could be less than predicted based on straight line attenuation, but daytime sound levels could be over 60 dBA. There are numerous residences near Ice Harbor, some as close as 0.5 mile. Average daytime sound levels at these residences could be greater than 60 dBA, and thus higher than the limits described in WAC 173-60. Peak sound levels could be greater than 70 dBA. Wildlife could be located closer to the sound sources, and thus could be exposed to higher sound levels that may affect behavior such as nesting or foraging.

Underwater sound levels would increase during earthen embankment breaching and subsequent levee construction around the remaining project structures, modifications of the structures to allow for full drawdown, and possible cofferdam installation to facilitate work. Limited information is available on underwater construction sound except for pile driving, which could be used to install cofferdams. The type of piles and estimated number of strikes are currently unknown and are needed to estimate the sound levels resulting from installation of cofferdams at the projects. However, it is known that unmitigated single-strike peak-sound levels can vary from around 177 dB to over 210 dB or more depending on the pile material and size, and many projects have measured cumulative sound exposure level (cSEL) values of 166 to 210 dB (WSDOT 2018). Thus, pile driving to install cofferdams could cause sound levels that injure fish (i.e., greater than 206 dB peak or 183 dB cSEL) or cause behavioral responses if appropriate mitigation is not implemented (Fisheries Hydroacoustic Working Group 2008). There are various ways to mitigate pile driving noise that can substantially reduce peak and cSEL levels such as vibratory hammers and bubble curtains (WSDOT 2018).

**SUMMARY OF EFFECTS**

In Regions A, B, and D, and at Dworshak in Region C, the proposed MO3 operational and structural measures are likely to be similar to the No Action Alternative and would result in negligible to minor noise effects.

In Region C, breaching of the four lower Snake River dams would result in temporary noise from construction activities. This noise could temporarily exceed state noise standard levels at nearby residences. Overall, construction noise related to dam breaching would result in moderate noise effects, particularly for nearby residents. However, once beaching work is completed, the local noise levels would be lower than under the No Action Alternative because operations and maintenance would cease at those project sites. In the long term, increased rail and vehicle traffic would likely result in a minor change to noise levels.

#### *3.14.3.5 Multiple Objective Alternative 4*

In addition to the operations and maintenance described for the No Action Alternative, MO4 would include changes to the spill regime at a number of projects, and structural modifications at all of the Snake River and lower Columbia River projects.

**OPERATIONAL MEASURES**

The proposed operational changes may alter the timing of peak flows, but would not likely result in flow over spillways, through turbines, or through fish passageways greater than existing peak flows experienced during annual periods of heavy runoff. Therefore, proposed operational measures would not change the potential magnitude of sound levels in the vicinity of any of the project sites for any region compared to the No Action Alternative, but could cause minor changes in the seasonal timing or duration of high-flow and high-spillway noise levels at any project.

**STRUCTURAL MEASURES**

No structural measures are proposed for the projects in Regions A or B under MO4 other than maintenance actions as described in the No Action Alternative and the impacts would not differ from those of the No Action Alternative.

The proposed modifications to the lower Snake River and lower Columbia River projects in Regions C and D in MO4 would require temporary use of standard construction tools and equipment. This equipment could combine to produce peak sound levels of 90 dBA or more (at 50 feet) for short periods; therefore, peak sound levels experienced by nearby people could be approximately 65 dBA during the day. This noise level may be noticeable, but would be temporary and would not be likely to cause annoyance to people in nearby residences or recreation areas. Wildlife nearer to the project sites would experience higher sound levels and could exhibit short-term behavioral responses; depending on the season, some wildlife may avoid foraging or nesting near a project while the structural modifications are performed. Some structural modifications could cause temporary increases in underwater sound levels, but these would likely be of shorter duration and much lower levels than those associated with pile driving, and depending on the location and timing of the modification, could be undetectable above the ambient operational project environment. The proposed structural measures would generally use similar equipment to some of the normal maintenance activities as described in the No Action Alternative.

**SUMMARY OF EFFECTS**

Overall, there would be a negligible to minor effect to noise levels from structural and operational measures under MO4.

## 3.15 FISHERIES AND PASSIVE USE

### 3.15.1 Introduction and Background

This section considers the social and economic values related to fish, and how they may be affected by the CRSO alternatives. The effects of the CRSO alternatives on potentially affected fish species are presented in Section 3.5. This section references those results in addressing how the commercial and ceremonial and subsistence fisheries that depend upon those fish species may be affected by the alternatives. The potential impacts to recreational fisheries are described in the Recreation/Environmental Consequences section.

### 3.15.2 Affected Environment

#### *3.15.2.1 Columbia River Basin-Origin Fisheries*

"Fisheries" are generally defined as a group of individuals or vessels that catch finfish or harvest shellfish, with specific commonalities in activity, including the fish species or stock targeted, the gear used, the location of activity, and the season of activity. The fish resources of the Columbia River Basin are caught in commercial, recreational, and tribal ceremonial and subsistence fisheries both within the Basin and in the ocean off the coasts of Washington, Oregon, California, British Columbia, and Alaska. Fish are a resource of critical importance to the tribes of the region. Every tribe in the Columbia River basin that signed a treaty with the United States reserved the right to harvest fish, and these rights were a critical component to those treaty negotiations. The Federal government has a trust responsibility to all federally-recognized tribes, which includes protection of treaty-reserved rights and tribal resources.

Commercial fisheries refer to fishing and catch, either in whole or in part, intended for commerce through documented sale, barter, or trade through licensed fish dealers. Commercial fishing for Columbia River Basin-origin fish is conducted by both tribes and the non-tribal public. The majority of commercial fishing in the Columbia River Basin generally occurs in the main stem of the Columbia River between the mouth of the river and just upstream of McNary Dam. Salmonid species, Chinook salmon and coho salmon specifically, dominate commercial catch of Columbia River Basin-origin fish both within the Columbia River and in Pacific Ocean fisheries. Commercial salmonid catch within the Columbia River Basin includes Chinook salmon, coho salmon, sockeye salmon, and steelhead. Other anadromous fish, including certain white sturgeon populations, American shad, and Pacific eulachon, are also caught commercially in the Columbia River Basin. Resident (non-anadromous) fish are not targeted in the Basin commercially, though some are caught incidentally and sold in tribal fisheries.

Tribal ceremonial and subsistence fishing is an important cultural, economic, and spiritual practice for American Indian tribes and Canadian First Nations in the Columbia River Basin. Salmon, in particular, are of critical importance to the spiritual and cultural identify of many of the region's tribes. Tribal ceremonial and subsistence fishing includes treaty-reserved catch by tribal members for ceremonial purposes, personal, familial, and community consumption, or sale of subsistence catch. Tribes in the region rely upon salmon for a variety of purposes. Salmon play a key role in numerous ceremonies of importance to regional tribes, including the first salmon ceremony, naming ceremonies, giveaways and feasts, and funerals. Beyond the cultural value provided by traditional uses of salmon, and the economic value associated with providing a low-cost source or protein, salmon is considered to provide an important health benefit to tribal members. Additionally, the use of salmon for these traditional purposes serves to facilitate the transfer of knowledge and culture across generations. As such, changes in the amount or quality of fish caught in tribal ceremonial and subsistence fisheries would result in social, cultural, and economic impacts that are unique to tribes, and distinct from impacts to non-tribal populations and communities (Figure 3-222).

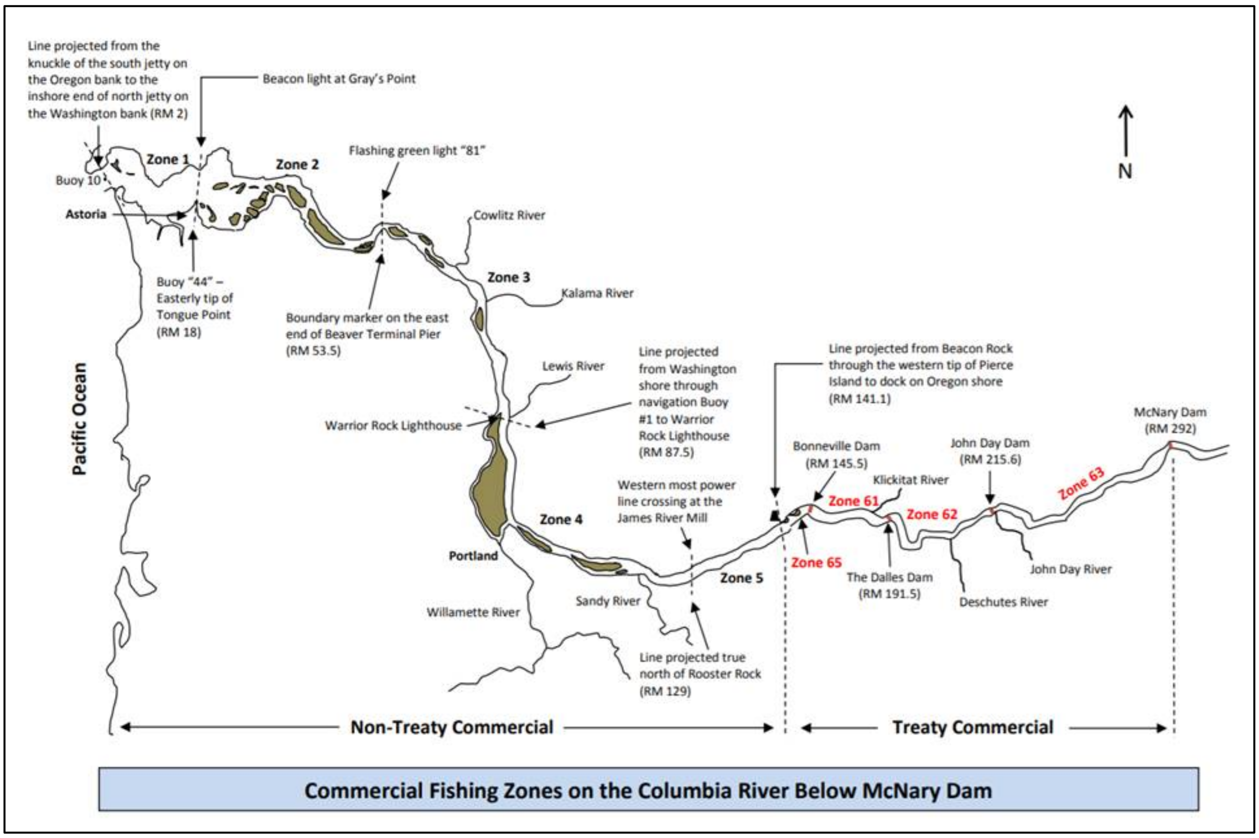


**Figure 3-222. Commercial Fishing Zones on the Columbia River below McNary Dam**

Source: ODFW (2018)

Recreational fisheries are inclusive of people who fish for sport or pleasure and charter vessels that provide a for-hire recreational fishing experience. Recreational fishery catch may be released or retained for personal consumption, but is not sold for profit. Columbia River Basin-origin fish support in-river, reservoir, and lake recreational fisheries in addition to supporting ocean fishery recreation. People fish by boat and from the shore, targeting anadromous species such as Chinook salmon, coho salmon, sockeye salmon, steelhead, shad, sturgeon, and eulachon. Cold water fishing for kokanee salmon and rainbow trout is popular in reservoirs and tributaries to the Columbia River mainstem, and fishing for resident species including suckers, pike, burbot, catfish, bass, sunfish, walleye, and perch is also popular. Recreational fisheries are discussed in detail in [Recreation/Affected Environment].

**MANAGEMENT OF COLUMBIA RIVER BASIN-ORIGIN FISHERIES**

Fisheries in the Columbia River Basin and those that rely upon Columbia River fish stocks are managed by numerous entities, including Federal, state, and tribal governments.[1] These entities are guided by a complex array of policies, laws, compacts, and agreements. The management of Pacific salmon fisheries in particular is complex, and involves numerous entities representing a variety of social, political, and conservation interests. Changes in allowable fishery harvest in the Columbia River Basin are a result of decisions made by state, Federal (i.e., NMFS), and tribal fishery managers based on a variety of environmental, biological, economic, and social factors.

The primary basis for fisheries management in the Columbia River Basin is *United States v. Oregon,* the ongoing Federal court proceeding first brought in 1968, *Sohappy v. Smith*, 302 F. Supp. 899 (D. Or. 1969), to enforce the reserved fishing rights of the Confederated Tribes of Warm Springs, Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe, and the Confederated Tribes and Bands of the Yakama Nation. The 1969 decision ruled that state regulatory power over American Indian fishing is limited because treaties made in 1855 between the United States and the tribes reserved the tribes' exclusive rights to fish in waters running through their reservations and at “all usual and accustomed places in common with citizens of [Oregon] Territory” (NMFS 2018f). Salmon and steelhead fisheries in the Columbia River have subsequently been managed by NMFS and other state, tribal, and local entities subject to provisions of *United States v. Oregon* under the continuing jurisdiction of the Federal court.[2] The 2018-2027 *United States v. Oregon* Management Agreement provides the current framework for managing fisheries and hatchery programs in much of the Columbia River Basin (NMFS 2018f). Once allocation between non-tribal and tribal fisheries is determined, harvest and management of the tribal allocation is at the discretion of the individual tribes. The four tribes fish together in the main stem of the Columbia River with the common goal of achieving their collective allocation goal, but each tribe establishes its own regulations guiding participation of their own members in the fisheries. There are not set rules or guidelines dictating the distribution of the tribal allocation among commercial and ceremonial and subsistence catch, but tribes generally prioritize ceremonial and subsistence needs over tribal commercial harvest. In certain tributaries, individual tribes co-manage fishing activity with the state (e.g., fishing in the Klickitat River is co-managed by the State of Washington and the 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).

For ocean fisheries, the PFMC, one of eight regional fishery management councils established by the Magnuson-Stevens Fishery Conservation and Management Act of 1976 to manage offshore fisheries, proposes management strategies for salmon fisheries occurring in the United States Exclusive Economic Zone, defined as the area from 3 to 200 nautical miles offshore, for approval by NMFS, which is the Federal regulatory entity.[3] The Pacific Coast Salmon Fishery Management Plan is the fishery management plan of the PFMC that covers commercial and recreational salmon fisheries off the coasts of Washington, Oregon, and California. The Pacific Coast Salmon Fishery Management Plan includes conservation measures, a framework for resource sharing, and strategies to ensure maintenance of sustainable salmon stocks (PFMC 2018a). Chinook (king) salmon and coho (silver) salmon are the primary salmon species covered by this plan along with important populations of pink salmon (PFMC 2016). Each year, the PFMC goes through a preseason management process to develop annual salmon management recommendations based upon catch in the previous year and anticipated abundance in the coming year (PFMC 1999a). This management process requires approval by NMFS. Within their determined allocation, individual tribes with retained rights to fish for salmon on the outer coast of Washington manage their own fisheries. Although several tribes are important participants in commercial fishing on the outer coast of Washington, only limited ceremonial and subsistence fishing occurs there (PFMC 2019).

The 1985 Pacific Salmon Treaty signed by the United States and Canada ensures conservation of fish populations and habitats and an equitable harvest of Pacific salmon and steelhead stocks among southeast Alaska, British Columbia, Washington, and Oregon. Sustainable fishing practices for optimal production and regulatory measures to avoid overfishing are key aspects of the treaty. Both the United States and Canada recognize that without regulation, each party would have an incentive to overfish. The treaty is therefore necessary to maintain salmon stocks and sustain fisheries over time (PFMC 1999). The Pacific Salmon Commission (PSC) was established to uphold the treaty and manage fisheries. The PSC is an international decision-making organization, composed of four Commissioners from the United States and Canada. This body handles on-going administration of the Pacific Salmon Treaty through advice from regional experts. It has responsibility for all salmon originating in the waters of one country which are subject to interception by the other, which affect management of the other country's salmon or affect biologically the stocks of the other country. The PSC is also charged with accounting for the conservation of steelhead trout while fulfilling its other functions (PSC 2018). As it is not a regulatory body, the PSC sends the plans and recommendations to the United States and Canadian governments for approval and implementation (PSC 2018).

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[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

**STATUS AND TRENDS OF FISHERIES FOR COLUMBIA RIVER BASIN-ORIGIN FISH**

**Ceremonial and Subsistence Fisheries**

Based on the treaties signed in 1855, four tribes have adjudicated treaty-based fishing rights to salmon in the Columbia River: Confederated Tribes and Bands of the Yakama Nation, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe of Idaho. The Shoshone-Bannock tribe has asserted tribal fishing rights under another treaty, and the Colville and Spokane tribes have also asserted such rights (PFMC 1999a). Ceremonial and subsistence fishing for other species of anadromous and resident fish is conducted by these and other tribes and Canadian First Nations throughout the basin.

Ceremonial and subsistence fisheries in the Columbia River Basin occur throughout the year (NMFS 2014). The number of fish allocated to ceremonial and subsistence fisheries and the gear used in this type of fishing are regulated by the tribes; the Columbia River treaty tribes have authority to regulate ceremonial and subsistence fishing by their tribal members (PFMC 1999a). Harvest of salmon for ceremonial and subsistence purposes occurs both in the mainstem and tributary areas of the mid-Columbia River, upper Columbia River, and lower Snake River regions. Subsistence fish are generally taken with dipnets, hoopnets, setnets, and hook-and-line gear from platforms primarily in the areas below The Dalles at Lone Pine and above Bonneville in the Cascade Locks area. Spears and gaffs are also used in specific tributary areas (PFMC 1999a). Ceremonial and subsistence harvest typically is focused on spring Chinook salmon; however, it can include coho salmon, steelhead, and summer and fall Chinook salmon (NMFS 2014). Some tribes in the Basin have lost access to ceremonial and subsistence fishing in usual and accustomed places due to extirpation of anadromous fish populations, including extirpation above federal dams in the Columbia River basin which were constructed without fish passage (Chief Joseph, Grand Coulee, and Dworshak Dams).

No comprehensive data exist for tracking past ceremonial and subsistence harvest in the Columbia River. Estimates developed for the 2014 Mitchell Act EIS concluded that subsistence catch from both the mainstem and terminal areas of the mid-Columbia River were, at minimum, 19,360 fish annually, of which 92 percent were Chinook salmon. In the upper Columbia River, ceremonial and subsistence catch was estimated to be approximately 3,000 fish annually, while at least 6,000 fish were estimated to be harvested annually in the lower Snake River (NMFS 2014).

The Yakama Nation continues to rely critically upon salmon and steelhead fishing for its way of life. Ceremonial and subsistence fishing occurs year-round on the Columbia River, and from April through October on its tributaries (Yakama Nation 1998 and Parker 1999, as cited in NMFS 2003). In addition to fishing in Zone 6 of the Columbia River, the Yakama Nation (along with other treaty tribes) maintains a right to conduct subsistence fisheries below Bonneville Dam, including on the Willamette River. Yakama Nation tribal members also conduct ceremonial and subsistence fisheries on the Yakima River, Klickitat River, Wind River, and Icicle Creek (a tributary of the Wenatchee River), as well as on the Little White Salmon, White Salmon, Wenatchee, Entiat, Methow, and Okanogan rivers (Yakama Nation 1998 as cited in NMFS 2003). Tribal members typically employ long-handed hoopnet gear from platforms over the river, though hook and line fishing has been increasing in popularity below the John Day and The Dalles dams. Gillnets may occasionally be used with agreement by the states when large quantities of fish are required for ceremonial purposes. Spring Chinook salmon are the most highly-valued species for cultural purposes (Yakama Nation 1998 as cited in NMFS 2003).

Salmon and steelhead fishing continue to be of utmost importance to the Confederated Tribes of Warm Springs. Several hundred tribal members conduct ceremonial and subsistence fishing from March through October, with an intensive period for four to six weeks within that window. These fisheries target spring, summer, and fall Chinook, sockeye salmon, and steelhead. Fishing occurs primarily in Zone 6 of the mainstem Columbia River, in the Deschutes River, and in the Willamette River, with some additional activity in the Hood and John Day Rivers (Fagen 1999 as cited in NMFS 2003).

Salmon and steelhead fishing are the foundation of the Confederated Tribes of the Umatilla Indian Reservation's way of life. Tribal members place an emphasis on using traditional locations and gear to harvest fish. Approximately 100 tribal members participate in ceremonial and subsistence fishing, with a particular interest in harvest of spring Chinook salmon in the Columbia River. Other species targeted in these fisheries, which vary seasonally, include summer and fall Chinook salmon, coho salmon, sockeye salmon, and steelhead. Tribal members fish in Zone 6 of the mainstem Columbia River and its tributaries, including the Umatilla River, Grand Ronde River, Tucannon River, John Day River, and lower Yakima River (James 1999 as cited in NMFS 2003).

The Nez Perce Tribe's culture, spiritual beliefs, economy, and way of life focus on salmon and steelhead. The Nez Perce Tribe conducts ceremonial and subsistence fisheries in Zone 6 of the Columbia River, as well as in much of the Snake River Basin (NMFS 2003). Some authors (Polissar et al. 2016) surmise that the tribe may have the largest number of tributary salmon and steelhead fisheries across Washington, Oregon, and Idaho, many of which occur year-round. The Tribe has usual and accustomed fishing places across 13 million acres identified as having been exclusively used and occupied by the tribes, including substantial portions of rivers including the Snake, Tucannon, Imnaha, Grand Ronde, Salmon, and Clearwater, as well as in the mainstem Columbia and elsewhere in the Columbia and Snake River basins. Harvest by Nez Perce tribal members includes Chinook salmon, coho salmon, sockeye salmon, dolly varden, cutthroat trout, brook trout, lake trout, rainbow trout, suckers, white fish, sturgeon, Northern pikeminnow, lampreys, and some shellfish (Polissar et al. 2016).

The Shoshone-Bannock Tribe have historically fished for salmon in the Columbia River Basin. Although tribal members do not participate in commercial fishing in the Zone 6 commercial tribal fishery, they do fish in the Salmon River and Snake River in Idaho. The tribe has also expressed interest in continuing to develop fisheries in other parts of Oregon and Washington (NMFS 2014).

Another important example of ceremonial and subsistence fishing in the upper basin is the Kootenai Tribe of Idaho (KTOI), who historically relied on fishing for subsistence. The Kootenai River itself is part of the Tribe's identity. Kootenai River white sturgeon are an important resource to the tribe, as are fish in Flathead Lake and areas along the Kootenai River. A recent report reviews available information regarding heritage fish consumption rates for the KTOI (Ridolfi 2016). While the reported heritage fish consumption estimates summarized in this report vary greatly, the cited ethnographic studies provide evidence of the importance of fish for subsistence and the culture of the Kootenai Tribe. The Kootenai Tribe operates the Sturgeon and Burbot Conservation Hatchery to reverse the decline of white sturgeon and burbot on the Kootenai River (Kootenai Tribe of Idaho 2018a). In addition, the Kalispel Tribe of Indians, who fish for subsistence in the Box Canyon Reservoir, harvest fish placed there from the Kalispel Tribal Hatchery. The Tribe rears juvenile largemouth bass at the hatchery (Kalispel Tribe 2018d). Fishing access permits and hunting permits for fishing and hunting on the Reservation are sold by the Natural Resource Department to non-members (Kalispel Natural Resource Department 2018). The Confederated Salish and Kootenai Tribes, with regulatory authority over fishing on the Flathead Reservation, charge fees for fishing permits for non-members, and the Division of Fish, Wildlife, Recreation, and Conservation regulates fishing activity carefully due to concern for the declining numbers of bull trout and west slope cutthroat trout (Division of Fish, Wildlife, Recreation, and Conservation et al. 2017).

Tribes report that overall catch of fish has declined dramatically from historical times, and they have lost a substantial portion of the salmon that were protected in treaties signed with the United States (Meyer 1999). The loss of salmon becomes more pronounced the further upstream one goes. For example, the Nez Perce report total tribal fishing harvest in the 1990s was approximately 160,000 pounds annually, which represents about 10 percent of estimated harvest during the mid-1800s (Meyer 1999). In the 1990s, the Confederated Tribes of the Umatilla Indian Reservation and the Confederated Tribes of the Warm Springs Reservation total tribal fishing harvest was approximately 77,000 pounds annually, which represents less than two percent of the two tribes' estimated harvest during the mid-1800s (Meyer 1999). Likewise, the Yakama Nation's total tribal fishing harvest was approximately 1.1 million pounds annually, which is estimated to represent about 20 percent of estimated harvest during the mid-1800s (Meyer 1999).

**Columbia River Commercial Fisheries**

The majority of commercial fishing in the Columbia River Basin occurs in the main stem of the Columbia River in six identified "zones" (see Figure 3-222) located between the mouth of the river and just upstream of McNary Dam.[4] The commercial fisheries are divided into tribal and non-tribal components, with most tribal commercial fisheries occurring between Bonneville and 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.

in Zones 1 to 5.[5] Commercial fisheries primarily target anadromous species such as Chinook salmon and coho salmon, and target resident species to a much more limited extent.[6]

Commercial Chinook salmon landings of Columbia River Basin-origin fish averaged 4.8 million pounds annually in the Basin and 1.7 million pounds annually in the ocean between 2013 and 2017, for a total annual average of 6.5 million pounds landed. The total annual average ex-vessel value during this period was $22.1 million. Commercial coho salmon landings averaged 0.8 million pounds annually, with an average annual ex-vessel value of $1.1 million (2013 through 2017). Commercial catch of Columbia River Basin-origin coho salmon was almost entirely from within the basin, with only negligible contributions from ocean catches.

***Salmonids***

Commercial fishing for salmonid species has been an important economic activity in the Columbia River Basin for thousands of years. During their expedition on the Columbia River, Lewis and Clark noted that approximately 50 tons of dried salmon were prepared by tribes fishing at Celilo Falls for trade exchange to other tribes (NW Power and Conservation Council 2019). The pace of commercialization and industrialization of fishing by non-tribal people accelerated throughout the 1800s. With the influx of European settlers and development of canning technologies, commercial fisheries developed rapidly (NMFS 2003). Despite spikes in activity in the 1980s and early 2000s, commercial salmon landings have generally trended downward since the 1930s (NMFS 2014) due to declines in salmon runs. Fishing pressure has been recognized among activities contributing to the decline in salmon runs in the Columbia River Basin and elsewhere (National Research Council [NRC] 1999).

The ex-vessel prices received for commercial salmon caught in the Columbia River Basin vary substantially by species (e.g., Chinook salmon vs. coho salmon), race (e.g., spring vs. fall), and stock (e.g., tules vs. brights).[7,8] In general, spring Chinook salmon have a higher commercial value per pound than other salmon species/stocks (Lothrop 2018).

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[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).

Figure 3-223 shows the annual value of commercial salmonid catches in the Columbia River Basin from 2007 to 2017, including both tribal and non-tribal harvest. The average annual value of coho salmon and Chinook salmon caught in the Columbia River Basin between 2013 and 2017 was $13.7 million based on an average annual landed weight of 5.6 million pounds.[9] Fall Chinook salmon consistently made up the largest proportion of the commercial catch value, followed by spring Chinook salmon. Treaty commercial fishermen are allowed to sell fish direct to consumers as well as to wholesale dealers. Ex-vessel prices do not reflect the higher prices paid in direct-to-consumer sales.

Commercial tribal fisheries primarily target Chinook salmon, coho salmon, sockeye salmon and steelhead. The largest proportion of the catch is composed of fall Chinook bright salmon, with a smaller proportion of spring Chinook salmon. Catch of coho salmon and fall Chinook tule salmon is minimal compared to other harvested species/stocks. Commercial non-tribal salmon fisheries target Chinook salmon and coho salmon; there is no permitted commercial non-tribal catch of steelhead, and sockeye salmon are not a primary target of these fisheries.

The average annual value of tribal commercial salmon catch within Zone 6 of the Columbia River between 2013 and 2017 was $8.2 million, based on an average annual landed weight of 3.4 million pounds. Tribal commercial value data were only available for Chinook salmon and coho salmon and, even then, data are only for sales made to licensed fish buyers, not direct sales to the general public which may be substantial. It is noted that Tribes do not draw a distinct separation between catch for commercial purposes versus catch for ceremonial and subsistence purposes. As such, tribes do not typically track the exact quantities of fish sold for commercial purposes, and since they do not require that fish be sold through licensed fish dealers, available fish ticket data likely underreports the quantity and value of tribal commercial catch (Ellis 2018). Consequently, any valuation under-represents the total value of commercial sales made by tribal fisherman (PFMC 2018).

The average annual value of non-tribal commercial salmon catch between 2013 and 2017 was $5.4 million based on an average weight of 2.2 million pounds of fish harvested annually. Fall Chinook bright salmon generally account for the largest proportion of the non-tribal commercial catch, followed by spring Chinook salmon, with smaller proportions of fall Chinook tule salmon and coho salmon.

Tribes do not issue commercial fishing permits or track participation in a comprehensive way, nor are data on participation readily available. Rather, tribal identification cards serve as fishing permits and any enrolled member can participate in any of the fisheries (Ellis 2018). Commercial non-tribal licenses to fish for salmonids in the Columbia River Basin are issued by the states of Washington and Oregon; there is no commercial fishing for anadromous species in Idaho.[10] There are presently 287 Columbia River Commercial Gillnet Permits for the State of 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.

certain circumstances (ODFW 2018a). In 2017, there were 247 Washington State permits for commercial salmon fishing in the Columbia River (Vernie 2018).

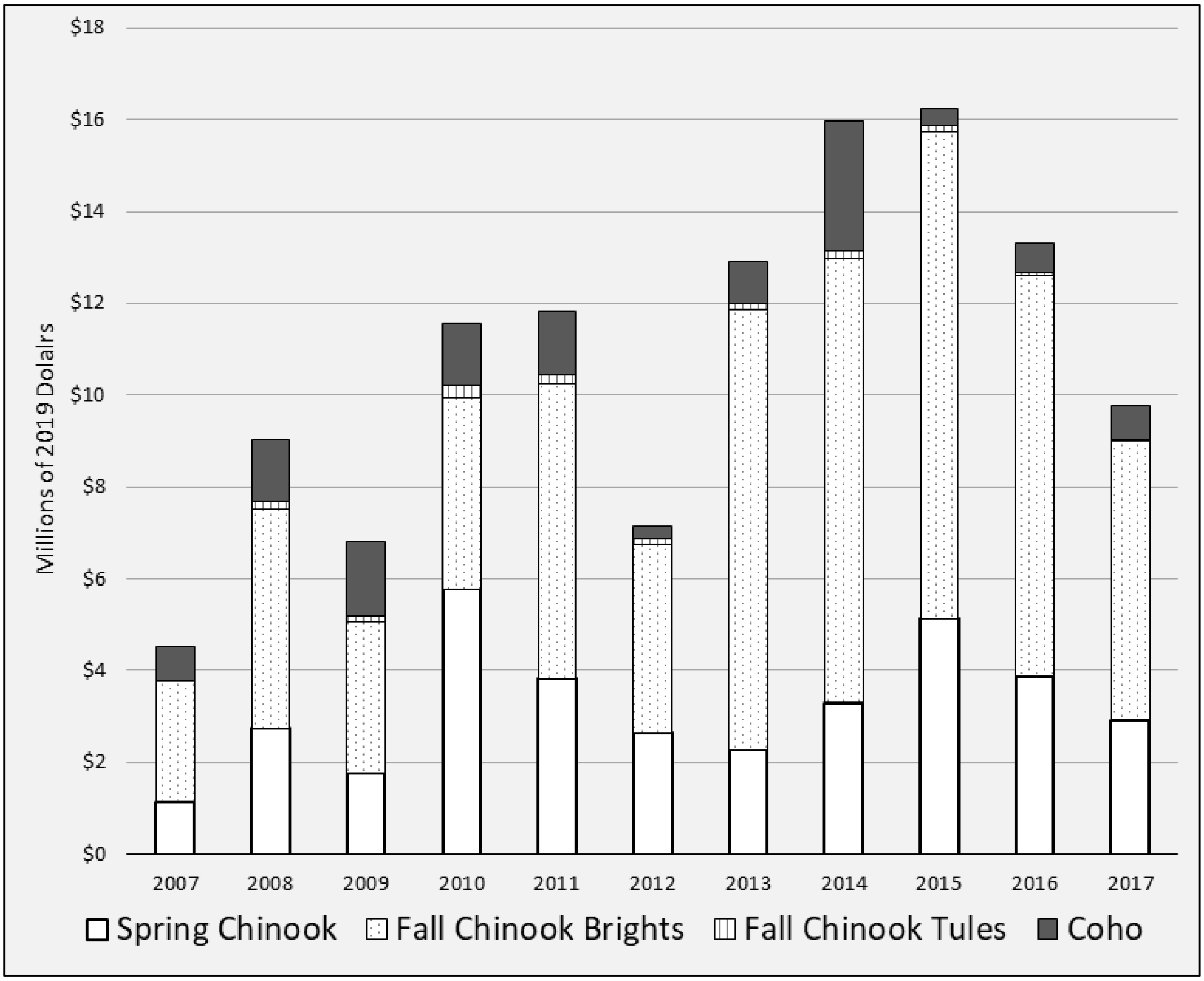


**Figure 3-223. Total Annual Value of Commercial Chinook Salmon and Coho Salmon Catch in the Columbia River Basin by Stock, 2007–2017, Millions of 2019 dollars**

Note: Value of tribal commercial catch accounted for in this figure includes only those sales made to licensed fish dealers. [11]

Source: Authors' calculations using data from PFMC (2018)

### *Other Anadromous Commercial Fisheries*

In addition to salmonids, several other anadromous species are caught for commercial 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).

American shad, and to a lesser extent, Pacific eulachon (also known as Pacific smelt or Columbia River smelt).[12,13]

- **White sturgeon** abundance downstream of Bonneville Dam has fluctuated greatly over the past few hundred years in response to human activity in the Columbia River Basin. In the late 1800s, the white sturgeon population dropped due to overfishing (ODFW/WDGW 2018b). Management actions in the mid-1900s helped white sturgeon populations rebound, but in more recent years the population has declined, due to fishing and predation by sea lions. Fluctuations in fish numbers has prompted strict regulation of catch size, daily and annual catch, catch season, and gear type used to catch white sturgeon (ODFW/WDFW 2018b). The Kootenai River population of white sturgeon is listed under the ESA and is not caught commercially.

  Commercial catch of sturgeon in Zone 6 has fallen steadily since 2001, but measured since 1996, catches have been cyclical as abundance has fluctuated (Sturgeon Management Task Force 2019; x). Gillnet, hook and line, and setline tribal commercial sturgeon fisheries occur in Zone 6, primarily in the winter. Between 2013 and 2017, the average tribal commercial landings of white sturgeon were 1,869 fish per year, although catch has steadily decreased from 2012 to 2017. In 2017, tribal sturgeon landings had an estimated ex-vessel value of $99,000 for 906 fish (ODFW/WDFW 2018b).[14] Non-tribal commercial catch was closed between 2014 and 2016 but was reopened in 2017. The total value of non-tribal commercial white sturgeon landings in 2017 was $127,000, for 1,227 fish.[15] The average non-tribal landings for the two years for which the fishery was open during the last five years was 1,620 fish.

- **American shad** Both tribal and non-tribal commercial fisheries target these fish during their return from the ocean, with runs extending from approximately mid-May through early August. Catch of the abundant runs of shad is regulated to minimize impacts to the overlapping runs of upriver Chinook salmon, sockeye salmon, and steelhead (ODFW/WDFW 2018a).[16]

  Data quantifying tribal commercial catch of shad in the Columbia River Basin prior to 2017 are not readily available. Fish not retained for subsistence are sold to commercial buyers or directly to the public. In 2017, 3,739 shad were sold by tribal fishermen to commercial buyers. Data for the total amount of retained shad and sales directly to the

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[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.

public are generally not documented or are unavailable (Ellis 2018; ODFW/WDFW 2018a).

The non-tribal commercial shad fishery is small and limited to an area within Zones 4 and 5 referred to as "Area 2S." Additional commercial shad harvest occurs via experimental gear permits, including beach and purse seine, outside of the Area 2S shad fishery. Between 2013 and 2017, average annual non-tribal commercial shad catch, inclusive of both the Area 2S and experimental gear fisheries, was 3,640 fish. Non-tribal commercial landings of shad in 2017 were amongst the lowest in almost 40 years, with only 2,007 shad landed. Non-tribal commercial catch of shad (again inclusive of the Area 2S and experimental gear fisheries) peaked in 2012 with a catch of over 29,000 fish but has since remained low due to the low market value for this species (ODFW/WDFW 2018a). In 2017, the price per pound of shad was only about $0.05, making the total non-tribal value of shad landings in that year $279.[17]

- **Pacific eulachon** usually enter the Columbia River Basin around December and spawn February through April. Spawning occurs in the mainstem and in tributaries downstream of Bonneville Dam which is where these fish are harvested. In March of 2010, eulachon was added to the list of threatened species under the Endangered Species Act (ESA). Eulachon catch was regulated prior to 2010, but the ESA listing triggered a complete closure of all eulachon fishing in the Columbia River Basin from 2011-2013 (ODFW/WDFW 2018b).

  Eulachon catch has fluctuated dramatically over the last decade, with a high of 18,558 pounds in 2014 and a three-year fishing closure resulting in a low of 0 pounds caught from 2011 to 2013. Almost all commercial catch of eulachon is non-tribal (ODFW/WDFW 2018b). The value of the 5,019 pounds of non-tribal commercial eulachon landings in 2017 was about $7,800.[18]

***Pacific Ocean Commercial Fisheries***

Anadromous fish originating from the Columbia River Basin contribute to recreational and commercial ocean fisheries in California, Oregon, Washington, British Columbia, and southeast Alaska. Columbia River Chinook salmon and coho salmon account for nearly 50 percent of the recreational harvest of those species, respectively, in northern Oregon and on the Washington coast. Columbia River Chinook salmon account for 22 percent of the recreational catch of that species in Southeast Alaska (NMFS 2014).[19] Columbia-basin origin Chinook salmon and coho salmon also contribute substantially to commercial fisheries in Oregon, Washington, and Southeast Alaska, and to a lesser extent, in British Columbia (NMFS 2014). This section describes the United States commercial ocean fisheries to which Columbia River Basin fish 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).

section then presents an estimate of the amount of the identified catch that is attributable to Columbia River Basin-origin fish.

<u>Ocean Salmon Catch</u>

Commercial ocean salmon fisheries consist of a tribal and non-tribal component. The majority of the tribal ocean fishing activity for salmon on the west coast is for commercial purposes, although some is allocated for ceremonial and subsistence (PFMC 2018). Tribes with treaty rights to fish commercially in west coast ocean fisheries include the Makah Tribe, Quinault Indian Nation, Quileute Tribe, and Hoh Tribe (PFMC 2016). As noted previously, only very limited ceremonial and subsistence fishing occurs on the outer coast (PFMC 2019). Treaty ocean fisheries are not required to obtain fishing permits from the states or NMFS to troll off the coast, unlike non-treaty trollers (NMFS 2014). Tribal ocean salmon troll landings are more generally focused on Chinook salmon over coho salmon, although in some recent years (2012 to 2014) landings of each were relatively similar and in 2009 more coho salmon were landed than Chinook salmon. The average annual landings of Chinook salmon and coho salmon between 2013 and 2017 was 70,621 fish.[20] The total value of tribal harvest of Chinook salmon and coho salmon has ranged from $0.7 million to $3.8 million annually between 2014 and 2017 (PFMC 2018).

Trolling is the only non-tribal commercial fishing method permitted in west coast fisheries (i.e., Washington, Oregon, and California) and troll vessels must obtain permits from the states to fish for salmon (NMFS 2014). The number of licensed salmon vessels has declined substantially since the early 1980s through 1990s (PFMC 2018). In 2017, a total of 2,194 vessels were permitted to fish salmon commercially in the ocean fisheries off the coasts of Washington, Oregon, and California (155 in Washington, 955 in Oregon, 1,084 in California). Of those, 31 percent reported landing salmon in 2017 (PFMC 2018). In contrast to the west coast fisheries (Washington, Oregon, and California), salmon are harvested commercially under different regulations in Southeast Alaska using a variety of gear types including purse seines, drift gillnets, set gillnets, and with hand and power troll gear (Alaska Department of Fish and Game [ADFG] 2018b). The non-tribal commercial troll fishery has the highest number of permitted participants, with 830 and 808 permits reporting landings of Chinook salmon and coho salmon, respectively in 2018, in Alaska (ADFG 2018c).

Nearly all of the total ex-vessel value of the non-tribal commercial ocean troll salmon fishery in Washington and Oregon (including, but not limited to, stocks other than Columbia River Basin-origin) is Chinook salmon. The average annual ex-vessel value of Chinook salmon caught in the non-tribal commercial ocean troll Chinook salmon fishery in Washington and Oregon between 2013 and 2017, including fish originating both within and outside of the Columbia River Basin, was $10.5 million based an annual average landed weight of 1.6 million pounds (PFMC 2018).[21] 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.

Alaska is more evenly distributed between Chinook salmon and coho salmon.[22] The average annual ex-vessel revenues for Chinook salmon and coho salmon between 2013 and 2017 was $19.5 million and $27.8 million, respectively (3.7 million pounds for Chinook salmon and 19.3 million pounds for coho salmon). The total annual value of salmon landed in southeast Alaska is over eight times as large as the landings in the ocean troll fishery off Washington and Oregon. However, a large portion of those landings are fish that did not originate in the Columbia River Basin.

Contribution of Columbia River Basin-Origin Fish to Commercial Ocean Fisheries

As described previously, salmon originating from the Columbia River Basin migrate to the ocean, where they contribute to fisheries in southeast Alaska, British Columbia, Puget Sound/Strait of Juan de Fuca, and coastal areas of California, Oregon and Washington (NMFS 2014). Fall Chinook salmon, summer Chinook salmon, and coho salmon are important components of these ocean fisheries. Other Columbia River Basin stocks do not contribute notably to these ocean fisheries (NMFS 2016). A number of sources provide estimates of the contributions of these Columbia River Basin stocks to ocean salmon fisheries, including NMFS (2016), Pacific Salmon Commission (PSC) (2018a), and 2014 Mitchell Act EIS (NMFS 2014). Because the NMFS (2016) and PSC (2018) estimates include both commercial and recreational fisheries and exclude contributions from coho salmon, our analysis relies on estimates from the 2014 Mitchell Act EIS (NMFS 2014).

The 2014 Mitchell Act EIS estimated the contribution of the Columbia River Basin-origin stocks of Chinook salmon and coho salmon specifically to commercial fisheries (NMFS 2014).[23] It estimated that Columbia River Basin-origin Chinook salmon composed 28 percent of commercial Chinook salmon catch in southeast Alaska, and 32 percent of commercial Chinook salmon catch off the Washington and Oregon coasts. That EIS also included estimates of Columbia River Basin-origin coho salmon in the commercial fisheries in southern Oregon and northern California of 11 percent and in northern Oregon and Washington of 1 percent (NMFS 2014).

Catch composition data for Columbia River Basin-origin stocks can be combined with ex-vessel value of landed catch to estimate the ex-vessel value of Columbia River Basin-origin Chinook salmon and coho salmon in ocean fisheries. In southeast Alaska, data from the ADFG show the annual average value of Chinook salmon catch between 2013 and 2017 in southeast Alaska as $19.5 million (ADFG 2018a). Therefore, the average annual value of Columbia River Basin-origin Chinook salmon in southeast Alaska is estimated to be $5.5 million (28 percent of $19.5 million). Data from NMFS (2014) suggest that the contribution of Columbia River Basin-origin coho salmon to southeast Alaska fisheries is not substantial.

The allocation scheme described previously for estimating the proportion of Chinook salmon and coho salmon of Columbia River Basin-origin caught in Oregon and Washington was applied

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[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.

to estimate ocean catch of Columbia River Basin-origin Chinook salmon and coho salmon in those states. Altogether, the estimated average annual ocean landings of Columbia River Basin-origin Chinook salmon from ocean fisheries in Washington, Oregon, and southeast Alaska are 1.7 million pounds while landings for coho salmon are much less (about 3,000 pounds). The average annual value of Chinook salmon of Columbia River Basin-origin caught in Washington, Oregon, and southeast Alaska ocean fisheries between 2013 and 2017 is estimated to be $9.5 million, while the estimated coho salmon value is only about $3,000.

**Economic Contributions of Columbia River Basin-Origin Fish to Pacific Northwest Region**

A number of efforts have attempted to quantify the total economic contribution of commercial fisheries to the Pacific Northwest region.[24] Below, we summarize a number of relevant findings of previous research specific to the value of salmon fishing in the Columbia River Basin:

- The 2017 Review of Ocean Salmon Fisheries developed by the PFMC found that income associated with the Columbia River Basin commercial salmon catch (combined non-tribal and tribal) was $14.3 million, which was 26 percent below the 2016 estimate of $19.4 million, corresponding with the trends in ex-vessel values observed in this fishery during that time (see Table 3-285) (PFMC 2018).
- The 2017 EIS for the *United States v. Oregon* harvest management agreement found that the harvest and primary processing of salmon caught in commercial fisheries in the Columbia River Basin (based on catch of five harvest indicator stocks) is estimated to generate $17.2 million in personal income and supports 419 full-time equivalent jobs in the region (NMFS 2017).

Additional efforts have described the value of all commercial salmon fishing in the region. Although these figures include value derived from salmon originating in areas both within and outside of the Columbia River Basin, they provide a sense of the importance of commercial salmon fishing generally to the region.

- A 2017 report for the PSC found that all commercial salmon fishing in southeast Alaska, British Columbia, Washington, and Oregon contributed an average of $256 million in GDP, $149 million in labor income, and 3,090 jobs to Washington's economy between 2012 and 2015. These impacts amount to approximately 0.1 percent of the state's total GDP, labor income, and employment each as compared to statewide totals in 2015. Commercial salmon fishing in those same locations was estimated to contribute $58 million in gross domestic product (GDP) (0.03 percent of statewide total), $35 million in labor income, and 910 jobs (0.1 percent of statewide total) to Oregon's economy (compared to 2016 statewide totals); and $417 million in GDP (0.8 percent of statewide total), $257 million in labor income (1.3 percent of statewide total), and 5,380 jobs (1.6 percent of statewide total) to Alaska's economy (compared to 2015 statewide totals) (Gislason et al. 2017; 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.

Department 2017; Alaska Department of Labor and Workforce Development 2015; United States Department of Labor 2019).

- A 2008 report by WDFW found that all commercial salmon fisheries of Washington contributed $22.6 million in personal income ($13.2 million for harvesters and $9.5 million for processors), 507 jobs, and had a net economic value of $7.5 million in 2006 (TCW Economics 2008). Wages and personal income provided by commercial salmon fishing accounted for approximately 0.02 percent of the statewide totals in each category compared to 2009 data (Washington State Employee Security Department 2010). No allocations between Columbia River Basin-origin fish and non-Columbia River Basin-origin fish were provided.

In addition to the regional economic contributions of anadromous fish species, particularly salmon, resident fish species also contribute notably to the economic health of certain communities. When viewed on a smaller scale, tribal commercial fisheries for resident fish are important economic drivers, especially for rural communities outside of the anadromous zone. Recreational fisheries for these species also contribute to the economy of these communities, as described in Section Recreation/Affected Environment.

**Social Importance of Commercial, Ceremonial and Subsistence Fisheries in The Columbia River Basin[25]**

***Tribal Fishing Activities***

Since time immemorial, salmon have been the central focus for the economies, cultures, lifestyles, and identities of the tribes of the Columbia River Basin. Over time, access of tribes to this critical resource has been diminished through competition with non-native harvesters and denial of access to traditional fishing, and more recently through, among other things, transformation of the rivers through dam construction (Meyer 1999). Despite the diminishment of the resource, salmon continue to be a key resource of critical importance to the tribes of the region for personal and family consumption, informal inter-personal distribution and sharing, community distribution, as well as ceremonial uses. Salmon play a central role in a variety of ceremonies important to regional tribes including winter ceremonials, the first salmon ceremony, naming ceremonies, giveaways and feasts, and funerals. In addition to these uses, salmon also facilitates the intergenerational transfer of knowledge and culture. Young people are taught by elders the use of fishing gears, preparation and preservation of salmon (e.g., smoking), and an appreciation for and awareness of their environment and the place of salmon within it.

To tribal communities, their obligation to salmon revolves around the concepts of renewal, reciprocity, and balance (Meyer 1999). CTUIR states in Appendix P that “salmon are the centerpiece of our culture, religion, spirit, and indeed, our very existence. As Indians, we speak 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**.**

interest groups. We do not bow to the will of powerful economic interests. Our people's desire is simple--to preserve the fish, to preserve our way of life, now and for future generations" (Donald Sampson, CTUIR). Beyond the cultural value provided by traditional uses of salmon, and the economic value associated with providing a low-cost source of protein, salmon provides an important health benefit to tribal members. Interviews presented by Meyer (1999) describe individual tribal perspectives on the importance of salmon to tribal communities. For example, a Nez Perce elder described traditional activities, including fishing, hunting, and gathering as "build[ing] self-esteem for Nez Perce peoples - and this has the capacity to reduce the level of death by accident, violence and suicide affecting our people. When you engage in cultural activities you build pride. You are helped to understand "what it is to be a Nez Perce" – as opposed to trying to be someone who is not a Nez Perce. In this way, the salmon, the game, the roots, the berries and the plants are the pillars of our world" (Leroy Seth, Nez Perce Elder).

"The loss of the food and the salmon is monumental - and it's all tied together. Food is a really big part of the Yakama culture - as it is elsewhere. Anywhere you look in the world, food carries culture. So if you lose your foods, you lose part of your culture - and it has a devastating effect on the psyche. You also lose the social interaction. When you fish, you spend time together - you share all the things that impact your life - and you plan together for the next year. Salmon is more important than just food. In sum, there's a huge connection between salmon and tribal health. Restoring salmon restores a way of life. It restores physical activity. It restores mental health. It improves nutrition and thus restores physical health. It restores a traditional food source, which we know isn't everything - but it's a big deal. It allows families to share time together and builds connections between family members. It passes on traditions that are being lost. If the salmon come back, these positive changes would start" (Chris Walsh, Yakama Psycho-Social Nursing Specialist).

#### *Non-Tribal Commercial Fishing*

The Columbia River gillnet communities are concentrated in small towns, villages, and rural areas adjacent to the Columbia River and areas of the Pacific coast where fishing permits can also be used. These communities can be identified using the number of fishing permits owned in an area, the number of fishing vessels owned in an area, and the total value of fish landed in an area (Martin 2008). Currently, more than two-thirds of licensed Columbia River Basin gillnetters live in four lower-river counties: Wahkiakum, Pacific and Grays Harbor in Washington, and Clatsop County in Oregon. The remaining one-third lives along the river, or in scattered locales throughout the two states and Alaska (Salmon for All 2018).

A previous study examined the social impacts of fishing restrictions and declining natural resources on these communities (Martin 2005). This study found that downturns in fishing seasons, coupled with declines in other natural resource-based industries, were negatively correlated with measures of community health. Social indicators such as poverty, mortality rates, and social service costs were greater in these communities in the years following fisheries decline relative to other parts of the state, while economic indicators such as per household income were within the lowest income category named in the U.S. Census.

On-going work by NMFS Northwest Fisheries Science Center (NWFSC) has developed community profiles and vulnerability assessments for coastal and some Columbia River Basin communities based upon methodology developed in the Northeast and Southeast regional offices of NMFS (Jepson and Colburn 2013). NWFSC collected data to assess coastal and select communities in the Columbia River Basin as far upstream as Klickitat County, Washington using social and demographic data from the U.S. Census Bureau and commercial fisheries data from the Pacific States Marine Fisheries Commission (PSMFC)'s Pacific Fishery Information Network (PacFIN) (Varney 2018). Each community receives a score for three separate indices (i.e., social vulnerability, commercial reliance, and commercial engagement) and is ranked into high, moderate, and low vulnerability categories based on its score relative to all communities evaluated within the study.

Figure 3-224 presents the results of the NMFS's analysis for communities in the Columbia River Basin that were included and for which commercial fishing data were available to develop rankings.[26] The communities of Ilwaco, Washington (about 950 residents) and Astoria, OR (about 10,000 residents) have been identified as being particularly vulnerable to changes in the fishing industry due to their high engagement in and reliance upon the commercial fishing industry, as well as social factors that indicate they may be less able to adapt to those changes. Chinook, Washington (about 450 residents) is also identified as vulnerable. In addition to gillnetting (considered self-employment), each of these three communities is reliant on fish and crab processing facilities for a substantial number of jobs (NMFS undated). In these three communities, between 15 and 18 percent of households live below the national poverty line, according to 2000 U.S. Census Data, relative to about 15 percent nationwide. It is important to note, however, that the analysis considers engagement in and reliance upon all fishing activities, and the degree to which these communities are specifically engaged in or reliant upon Columbia River Basin fisheries is not discernable from these results. Community profiles of west coast fishing communities developed by NMFS indicate that a large number of residents in Astoria, for example, participate in the lower Columbia River gillnet fishery, targeting salmon, shad, sturgeon, and eulachon. However, residents of these communities are also involved in other fisheries including Dungeness crab, coastal pelagic species, groundfish, and shrimp (NMFS 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.

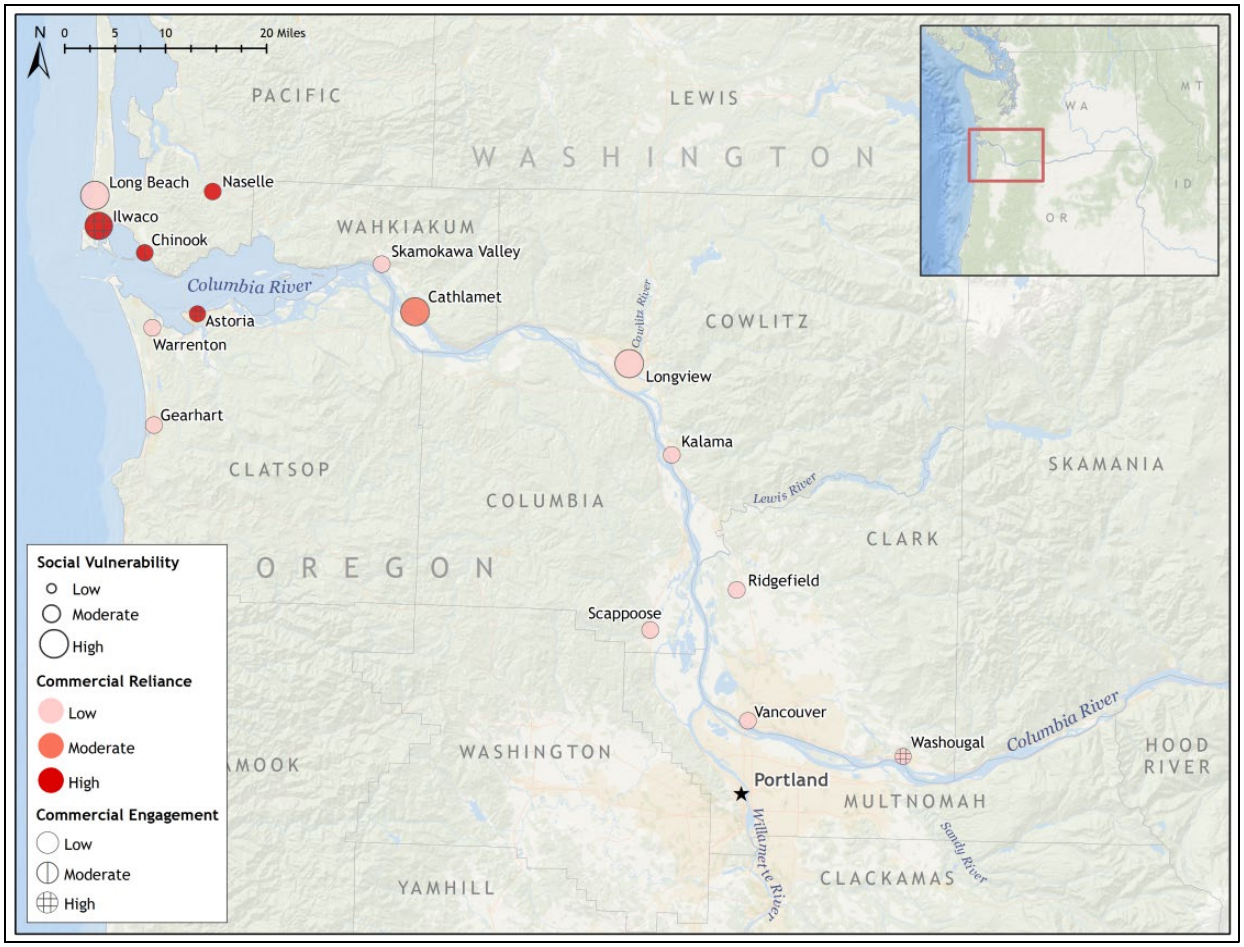


**Figure 3-224. Results of NMFS Community Vulnerability Assessment for Columbia River Basin Communities Downstream of Klickitat County, Washington**

Note: The Commercial Engagement index is used to measure how a community interacts with the fishing industry in order to determine how the community will respond to the proposed MOs. The Commercial Reliance index is used to measure how reliant a community is on the fishing industry, to assess how it will be affected by the changes of the proposed MOs. The Social Vulnerability index considers how resilient a community's population may be to changes in the fisheries on which they depend.

Commercial Engagement and Reliance scores reflect all commercial fishing activity, not just that portion which is dependent upon Columbia River Basin-origin fish.

Source: Map created by author using data from Varney (2018)

### *3.15.2.2 Passive Use*

Passive use values, also referred to as "non-use values," are the values people hold for the continued existence of a resource beyond any current or future use.[27] These values are thought 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).

functioning.[28] While different definitions are used across studies, economists generally see these values are motivated by three key factors:

- Existence value, defined as the benefit gained simply from knowing the resource exists;
- Option value, allowing for potential use of the resource in the future; and/or
- Bequest value, reflecting a desire to ensure the continued existence of the resource for future generations.

The total economic value (TEV) of a resource is the combined total of all use values and passive use values, which together represent the full value a resource brings to society. Although passive use values research generally focuses on fish and wildlife species, theoretically people may hold passive use values for many types of resources. In the context of the Columbia and Snake rivers, salmon are a resource for which passive use values are often considered an important part of TEV. Existing research on passive use values for dam breaching and free-flowing rivers also typically focuses on the expected benefits to salmon or other fish and wildlife species (e.g., Douglas and Taylor 1999, Loomis 1996a, 1996b, Mansfield et al. 2012, Hanemann et al. 1991). Use values for salmon contain both market (e.g., commercial fisheries) and non-market (e.g., recreation) components,[29] while passive use values are strictly not observable in a market or in people's behavior. TEV values, therefore, should not be summed with other values because it may result in double-counting. This section summarizes the findings of existing studies that have evaluated passive use values for Pacific salmon and other Columbia River Basin resources, and describes how this research relates to the CRSO EIS. Given the limitations of the existing literature and uncertainty of the changes in overall fish abundance predicted under each MO, this EIS does not include a quantitative benefit transfer of passive use values. It does, however, acknowledge that the literature demonstrates that the general public holds passive use values, and that the population that may experience social welfare benefits from increased salmon populations may be geographically far-reaching.

**METHODS FOR QUANTIFYING PASSIVE USE VALUES**

Quantifying passive use values requires survey-based "stated preference" methods. The most common stated preference methodology employed in passive use value research is contingent 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.

to-pay (WTP) for a given resource or ecological improvement.[30] These surveys present respondents with hypothetical scenarios for changes in a given resource, and a "price tag" associated with each scenario, then asks the respondents to either choose between scenarios or assign a yes/no value to a given scenario and cost option. Responses are then used to calculate an average WTP for each scenario among respondents.

Benefit transfer, a methodology that applies results from existing relevant studies to a new resource or context, is commonly used when primary survey research is not feasible or practical. Several types of benefit transfer methods exist, and all apply the results of one or more studies to another context by making adjustments based on the differences between the existing studies and new context. Benefit transfer analysis relies on objective analysis of whether the results of one analysis can be applied elsewhere, and on the analyst to "make a case" regarding the applicability of results from one study to another. Several sources identify best practices when using benefit transfer (EPA 2014; Johnston et al. 2015; OMB 2003), and others acknowledge the challenges and shortcomings of the methodology (Newbold et al. 2018).

**RESEARCH ON PASSIVE USE VALUES FOR SALMON**

This review prioritizes studies focused on regional fish species found in the Columbia and Snake rivers and includes results from both primary survey research and benefit transfer methods. Existing research also suggests that people may hold passive use values for other resources and species found in the Columbia and Snake River Basins, including marine species that prey on salmon as well as other threatened and endangered species. Additionally, the economics literature includes research on passive use values for free-flowing rivers. These studies generally bundle the environmental changes associated with free-flowing rivers, including, for example, specifying effects on fish populations. This section focuses on passive use research on salmon.

While passive use values are distinct from use values, it is difficult to design a survey that can isolate passive use from use components of TEV. This is because, as previously described, survey respondents may value a resource, such as salmon, for multiple reasons, including recreation, commercial fishing, ecological importance, or passive use. It may be difficult for survey respondents to divide the value they hold for the resource into the specific components (e.g., Richardson and Loomis 2009). For this reason, many studies focus on quantifying TEV rather than exclusively passive use values. Some studies, however, conduct analysis on a population sample that is not expected to hold use values for the resource (e.g., people who live in the nearby watershed but indicate they do not participate in fisheries or recreation, or 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.

to estimate a value that may be interpreted as passive use. This literature summary includes both passive use and TEV studies.

A total of 18 studies were identified that estimate passive use or TEV for salmon of relevance to the Columbia River Basin ecosystem, including 13 primary studies and 5 studies employing benefit transfer methods. Primary survey studies regarding Pacific salmon are listed in Table 3-285 and are summarized in below. Related benefit transfer studies are also summarized in the text below.

Every primary study included in this review identifies positive average WTP values for Pacific salmon, meaning the existing body of research consistently finds that the surveyed populations hold some value for salmon beyond any direct or indirect use. Generally, these studies focus on eliciting information on the value people hold for specified increases in populations of particular types of salmon. There are a few studies, however, that focus on a broad range of effects related to dam removal and the associated impacts on river flow, which include but are not limited to changes in salmon populations. Moreover, the studies represent a range of baseline salmon population abundance and hypothetical population change scenarios, including both increases in percent over a baseline level or “downlisting” from endangered to threatened or recovery. The studies also reflect surveys administered among different respondent populations, which vary geographically, some of which are now quite dated (up to 25 years old). For these reasons, the results of the studies cannot be directly compared to one another.

**Primary Research Specific to Removal of the Lower Snake River Dams**

One existing primary survey study is specific to the values individuals assign to the salmon affected by the lower Snake River dams. ECONorthwest conducted an analysis based on a survey among active voters in Washington State conducted by Save Our Wild Salmon (ECONorthwest 2019). Specifically, the relevant survey question asked respondents if they were willing to pay an additional $x (where values were randomly assigned across respondents) on their electric bill to restore wild salmon and improve water quality by removing four dams on the lower Snake River. ECONorthwest analyzed the survey responses to estimate an average WTP of $26 to $48 per household per year, depending on the discount rate applied. They multiplied these values by the number of households in the five-state region referenced in the 2002 EIS to estimate a population-level, 20-year present value of passive use benefits ranging from $5.1 billion to $7.0 billion assuming a seven percent discount rate (equivalent to $12 to $16 billion assuming a 2.75 percent discount rate).[31] Based on the survey question, the results of this analysis are likely to reflect TEV rather than the passive use component exclusively, and may potentially reflect the respondents’ perceptions of other outcomes related to dam removal. While the single question survey focuses specifically on the removal of the lower 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.

study applies WTP values reported by Washington households to all households across four additional states.

**Benefit Transfer Studies**

Existing benefit transfer studies relevant to the salmon in the Columbia and Snake Rivers that make use of these primary studies do not converge around a single WTP value, and their resulting estimates are highly influenced by the benefit transfer method selected. For example, Weber (2015) compares four benefit transfer methods and finds very different WTP values per household depending on the method applied. Moreover, the results of these benefit transfer studies generally reflect TEV and not the passive use component exclusively. Finally, in some cases per household values are estimated while in others only population aggregates are reported.

For example, Richardson and Loomis (2009) conducted an update of a meta-analysis originally published by Loomis and White (1996) that explores WTP across multiple endangered and threatened species types and offers their resulting mathematical model for benefit transfer to other contexts. Their models integrate findings of several primary studies included in this review, and both studies make clear that their resulting estimates are TEV, not passive use. Based on existing literature, Loomis and White (1996) find an average WTP of $102 per household for the increase in population of various Pacific salmon and steelhead while Richardson and Loomis (2009) find an average WTP of $298 per household for increase in population of various Washington state anadromous fish. The larger value reported by Richardson and Loomis (2009) reflects an increase in reported WTP values across surveys over time.

A report by Earth Economics applied the mathematical model provided by Richardson and Loomis (2009) to estimate the “existence values” for salmon under present and hypothetical future conditions in the Columbia River (Flores et al. 2017). This study estimates an aggregate existence value across all 2.8 million households in the Columbia River Basin of $38.4 million annually for the current scenario versus $1.1 billion annually for a scenario where salmon populations increase by 51 percent. There is some uncertainty about the method used to estimate the 51 percent increase salmon population levels for the future scenario. Moreover, the study describes these estimates as “existence values” (i.e., synonymous with passive use values) that are additive with other types of values quantified and described in their report, including commercial fishing, recreational fishing, and cultural values. Based on the method employed to quantify these values, however, they are more likely reflective of a TEV estimate and should not be summed with other types of values.

Another study considers recovery of spring Chinook salmon in the Willamette Valley of Oregon as a case study for investigating various benefit transfer techniques for TEV estimation (Weber 2015). Six of the studies identified in this review are used in the Weber (2015) study. The study finds that households in the immediate watershed are WTP $49 to $4,645 per household to double the spring Chinook salmon population, depending on the transfer model employed. This broad range is indicative of the variability of the source studies used to support the benefit transfer and leads the study to conclude that studies attempting to leverage the existing literature to value changes in salmon should employ multiple transfer approaches as sensitivity analysis or else identify a single study that closely matches the policy context for the benefit transfer. The study also notes that the research available for benefit transfer is limited in its distinction of wild and hatchery salmon, which makes interpretation for policy purposes difficult as wild and hatchery salmon may be affected differently and it is unclear if the surveyed populations value them differently.

The Lower Snake River Juvenile Salmon Mitigation Feasibility Report and Environmental Impact Statement included a benefit transfer for salmon specific to the breaching of dams on the lower Snake River (Corps 2002). For the dam removal scenario, the 2002 EIS estimates passive use values associated with an increase in wild salmon returns ranging from $31 to $414 million per year among households in the Pacific Northwest and California. The Independent Economic Analysis Board of the Northwest Power Planning Council review of the study (2000) identified methodological concerns with this study, including that it did not account for potential diminishing returns in assuming a single per fish value and multiplying it by the estimated returns.

**Relevance to the CRSO EIS**

The existing literature on passive use and TEV for salmon is generally based on changes in overall salmon abundance. The life cycle for anadromous fish is complicated and various aspects of fish survival may be affected by each CRSO EIS action alternative (e.g., juvenile in-river survival, adult returns). Thus, the CRSO EIS assesses effects of the MOs on fish in terms of multiple different metrics; changes in abundance are only quantified for some salmon stocks.

This analysis considers the applicability of the existing literature to the CRSO EIS given best practices for benefit transfer. While the existing literature identifies a positive WTP for improving salmon populations, it is also clear that the specific value of a given population-level effect is uncertain. Studies conducted 20 to 30 years ago rely on outdated survey methodologies and baseline conditions for salmon populations, calling into question whether they accurately reflect current values held by the public. The more recent surveys have generally involved small sample sizes, and narrowly define the resource change (e.g., “restoring” salmon or removing a specific dam). Finally, the study that most closely matches the policy context of an MO, the ECONorthwest lower Snake River dam removal study, presupposes that the dam breach will “restore” wild salmon.

Best practices for benefit transfer identified in OMB Circular A-4 describe that meeting all criteria is difficult and that “professional judgment is required in determining whether a particular transfer is too speculative…” (OMB 2003, 26). Given the limitations of the existing literature, this EIS does not include a quantitative benefit transfer of passive use values. This analysis acknowledges that the general public holds passive use values, and that the population that may experience social welfare benefits from increased salmon populations may be 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)<br>$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)<br>$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<br>$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<br>$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) |

Notes:
Only primary studies are included in this table. Benefit transfer studies are described in the main text.
All WTP values adjusted from their survey year to Q1 2019 USD using a GDP deflator from the Bureau of Economic Analysis (Table 1.1.9).

## 3.15.3 Environmental Consequences

### *3.15.3.1 Methodology*

This analysis evaluates potential impacts on fisheries by referencing the potential effects on relevant fish populations, as described in Section 3.5. There are no anticipated effects to fisheries in Canada under any alternative.

### *3.15.3.2 No Action Alternative*

**SOCIAL WELFARE EFFECTS**

The social welfare effects analysis considers the extent to which the effects of the alternatives on fish (as described in Section 3.5) affect the economic value of commercial fisheries.[32,33] Ongoing trends with regard to both non-tribal and tribal commercial fisheries would be expected to continue under the No Action Alternative. Under this alternative, most non-tribal commercial fishing activity would continue to occur downstream of Bonneville Dam, while tribal commercial fishing would continue to be concentrated primarily between Bonneville Dam and McNary Dam (Region D).

Under the No Action Alternative, Chinook salmon and coho salmon would continue to provide the greatest commercial value of all species originating from the Columbia River Basin. Because there is no clear trend, this analysis assumes that catch would continue consistent with recent 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.

would be anticipated to continue to make up the largest proportion of the commercial catch value under the No Action Alternative.

Chinook salmon from the Columbia River Basin will also contribute substantially to ocean fisheries in Oregon, Washington, and Alaska. Trends in ocean catch of Chinook salmon over the last ten years suggest that landings and value of Chinook salmon has fluctuated between years, but has ranged between $13 million and $25 million in Alaska, of which approximately 28 percent are of Columbia River Basin origin. In Oregon and Washington, value has ranged between $2 million and $18 million in Oregon and Washington, of which approximately 32 percent are of Columbia River Basin origin. This analysis assumes these general ranges of value for ocean fisheries will persist in the future under the No Action Alternative.

Under the No Action Alternative, steelhead would continue to be an important commercial target for tribal commercial fishermen in the area between Bonneville Dam and McNary Dam (Region D). Under the No Action Alternative, white sturgeon and, to a lesser extent, American shad, and Pacific eulachon would continue to be caught for commercial purposes in the Columbia River Basin. Commercial fishing activities for these species would be concentrated below McNary Dam. Commercial catch of sturgeon in Zone 6 has fallen steadily since 2001, but measured since 1996, catches have been cyclical as abundance has fluctuated (Sturgeon Management Task Force 2019). This fishery is expected to persist at relatively low numbers of fish caught, under the No Action Alternative. Commercial interest in shad has fluctuated dramatically over the last half-decade, and the low price of shad has resulted in a lessened interest in this fish commercially in recent years. Commercial catch of shad is expected to be minimal under the No Action Alternative. Under the No Action Alternative, catch of eulachon is expected to continue at low levels.

**REGIONAL ECONOMIC EFFECTS**

Under the No Action Alternative, commercial fishing would continue to provide important contributions to the regional economies of the Columbia River Basin. Catch and processing of fish from the Columbia River Basin, as well as related service industries that support these fisheries, would continue to provide employment and income to the region. Communities such as Astoria, Oregon; Illwaco, Washington; and Chinook, Washington would continue to be particularly dependent upon the commercial fishing industry.

**OTHER SOCIAL EFFECTS**

**<u>Non-Tribal</u>**

Commercial gillnetting, the primary means of non-tribal salmon fishing in the Columbia River Basin, is a tradition passed down through generations and is an important element of cultural identity and the social fabric of many coastal Oregon and Washington communities. More than two-thirds of licensed Columbia River Basin gillnetters live in Wahkiakum, Pacific, and Grays Harbor counties in Washington, and Clatsop County in Oregon. The remaining one-third lives along the river, or elsewhere in Oregon, Washington, and Alaska (Salmon for All 2018). Given their high level of involvement in the fishing industry, and existing social conditions, the communities of Ilwaco, Washington, Astoria, Oregon, and Chinook, Washington are particularly vulnerable to changes in fishing activity. Although communities such as Astoria are heavily involved in gillnetting, fisheries such as Dungeness crab, coastal pelagic species, groundfish, and shrimp also support the fishing industry in these communities (NMFS undated). The social and economic importance of salmon fishing to these communities is not anticipated to change under the No Action Alternative.

**<u>Tribal</u>**

In addition to participating in commercial fishing, tribes in the Columbia River Basin also rely upon numerous anadromous and resident fish species for ceremonial and subsistence purposes. Under the No Action Alternative, catch of salmon, steelhead, and other culturally important species for ceremonial and subsistence purposes would continue to occur both in the mainstem rivers and in tributaries throughout the Basin. Ceremonial and subsistence fishing activities would continue to target spring-run Chinook salmon in particular, but would also include catch of coho salmon, steelhead, summer- and fall-run Chinook salmon, lamprey, kokanee salmon, bull trout, and burbot, among others. Ongoing effects of inundation and reservoir fluctuation would continue to have adverse effects on resident fish availability for ceremonial and subsistence uses under the No Action Alternative.

**SUMMARY OF EFFECTS**

Commercial fishing and ceremonial and subsistence fishing for anadromous fish would continue to contribute substantially to the economy of the region, as well as to the social fabric and culture of both non-tribal and tribal communities. Adult and juvenile migration and survival of anadromous species, and the fisheries that depend on them, would continue to be limited by conditions in the basin. Ceremonial and subsistence fishing for resident species would continue to play a critical role in maintaining tribal culture and community, particularly for tribes in the upper basin, and the survival of the species on which these fisheries depend would continue to be limited by existing conditions.

#### *3.15.3.3 Multiple Objective Alternative 1*

**SOCIAL WELFARE EFFECTS**

The social welfare effects analysis considers the extent to which the effects of the alternatives on fish (as described in Section 3.5) affect the economic value of commercial fisheries.[34,35] Under MO1, in Region C, effects to anadromous fish range from potential negligible beneficial 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.

species are anticipated to have the potential for minor adverse effects, particularly sockeye salmon and fall Chinook salmon, based on warmer summer water temperatures. The effects of MO1 in Region D are anticipated to be similar to those in Region C. MO1 is not anticipated to have effects on anadromous species that differ markedly from the No Action Alternative in Region B. To the extent that changes in fish abundance results in corollary changes in commercial fish harvest, MO1 is anticipated to have mixed social welfare effects ranging from minor adverse to minor beneficial effects to commercial fisheries targeting these populations.

**REGIONAL ECONOMIC IMPACTS**

Because MO1 is likely to result in minor adverse to minor beneficial changes to commercial fisheries relative to the No Action Alternative, regional economic effects associated with these changes are anticipated to be minor to negligible under MO1.

**OTHER SOCIAL EFFECTS**

**Non-Tribal**

Because MO1 is likely to result in generally minor to negligible changes to commercial fisheries relative to the No Action Alternative, changes to other social effects of commercial fishing are also anticipated to be minor to negligible under MO1.

**Tribal**MO1 is predicted to have some minor beneficial effects on certain anadromous fish species and minor adverse effects for others. Overall, effects are predicted to be minor to negligible. MO1 is thus likely to result in minor to negligible changes to ceremonial and subsistence fisheries for anadromous species relative to the No Action Alternative.

MO1 may result in minor to moderate effects, both beneficial and adverse, to resident fish, which could have corresponding effects to ceremonial and subsistence fishing activities. In Region A, MO1 would have minor to moderate adverse effects on bull trout and Kootenai River white sturgeon. Burbot may be similarly affected. In Region B, MO1 would have negligible, minor to localized moderate adverse effects to resident fish in Lake Roosevelt such as kokanee, redband rainbow trout, white sturgeon, and burbot, stemming from increased entrainment, varial zone effects (important for migration), and in the river reach, a minor reduction in sturgeon recruitment in Region B. In Regions C and D, MO1 would have minor adverse effects to resident fish due to warmer summer water temperatures, reduced flows, or increased TDG and potential for gas bubble trauma. Ceremonial and subsistence fishing for resident species could be adversely affected in these areas.

**SUMMARY OF EFFECTS**

MO1 is anticipated to result in minor to negligible effects on commercial and ceremonial and subsistence fisheries for anadromous fish species as compared to the No Action Alternative. As a result, social welfare effects, regional economic impacts, and other social effects are likewise anticipated to be minor to negligible. Potential localized adverse effects on resident fish may result in some adverse effects on ceremonial and subsistence fisheries across all regions.

### *3.15.3.4 Multiple Objective Alternative 2*

**SOCIAL WELFARE EFFECTS**

The social welfare effects analysis considers the extent to which the effects of the alternatives on fish (as described in Section 3.5) affect the economic value of commercial fisheries.[36,37] MO2 is anticipated to have a number of adverse effects on anadromous fish populations across the regions. In Region B, Upper Columbia River salmon and steelhead below Chief Joseph Dam would be adversely affected. Under MO2, decreased abundance of Snake River spring Chinook salmon and Snake River steelhead are predicted by the CSS model in Region C. In Region D, decreased abundance of Snake River spring Chinook and Snake River steelhead, upper Columbia River spring Chinook salmon, and decreased in-river survival rates of upper Columbia River steelhead would contribute to adverse effects on commercial fishing opportunities on the Columbia River. To the extent that these adverse effects result in reduced adult abundance for these populations, there is the potential for adverse changes in commercial fish catch and associated social welfare effects for these species.

**REGIONAL ECONOMIC IMPACTS**

Because MO2 is likely to result in adverse effects on the adult abundance of certain commercially important fish populations compared to the No Action Alternative, MO2 may result in some adverse regional economic effects if reductions in commercial fishing catch occurs.

**OTHER SOCIAL EFFECTS**

**Non-Tribal**

Because MO2 is likely to adversely affect some commercially important fish populations, MO2 may result in some adverse social effects if the level of commercially caught fish decreases under this alternative compared to the No Action Alternative.

**Tribal**

MO2 may result in adverse effects on anadromous fish of great ceremonial and subsistence value to tribes. As described above, adverse effects to these species are anticipated in Regions 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.

ceremonial and subsistence fisheries, MO2 may result in adverse social and cultural effects on tribes.

MO2 is anticipated to result in adverse effects on resident fish in localized areas. In Region A, higher winter flows downstream of Libby Dam on the Kootenai River in late fall and downstream of Hungry Horse dam in the winter may result in adverse effects to resident fish. MO2 may also result in decreased habitat for white sturgeon on the Kootenai River. In Region B, MO2 may result in increased entrainment for resident species in Lake Roosevelt such as bull trout, kokanee, rainbow trout, and burbot. In Region C, adverse effects to kokanee at Dworshak Reservoir are anticipated. Ceremonial and subsistence fisheries relying upon these resident fish would also be adversely affected if these effects result in decreased opportunities to harvest these fish. Adverse effects to ceremonial and subsistence fisheries of resident fish would occur in Regions A, B, and C under MO2.

**SUMMARY OF EFFECTS**

The fish analysis predicts that MO2 will generally result in moderate adverse effects to both anadromous and resident fish species across all regions, although there may be some minor to major adverse effects in localized areas. To the extent that the predicted effects result in decreased abundance of these species, and a decreased opportunity for commercial and ceremonial and subsistence harvest of these species, minor to moderate adverse social and cultural effects may be anticipated under MO2.

### *3.15.3.5 Multiple Objective Alternative 3*

**SOCIAL WELFARE EFFECTS**

The social welfare effects analysis considers the extent to which the effects of the alternatives on fish (as described in Section 3.5) affect the economic value of commercial fisheries.[38,39] Under MO3, the breaching of the dams will result in short-term adverse effects for most species in Region C, but long-term beneficial effects on key anadromous species of commercial importance, particularly Snake River Chinook salmon and steelhead. In Region D, long-term increases in abundance of salmon and steelhead, as well as white sturgeon, are also anticipated. To the extent that these results indicate that adult fish abundance will increase in the future, benefits to commercial catch for these species may occur.

**REGIONAL ECONOMIC IMPACTS**

Because MO3 is likely to result in benefits to certain commercially important anadromous fish 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.

increases in regional economic effects of commercial fishing activities if increases in commercial fishing catch occur.

**OTHER SOCIAL EFFECTS**

**<u>Non-Tribal</u>**

Because MO3 is likely to benefit some commercially important anadromous fish populations compared to the No Action Alternative in the long term, MO3 may result in some beneficial social effects, if the level of fish caught for commercial, increases under this alternative.

**<u>Tribal</u>**

Because of the anticipated long-term benefits of MO3 on anadromous fish species, MO3 may result in beneficial tribal cultural and social effects, if the level of fish caught for ceremonial or subsistence purposed increases under this alternative. However, MO3 may result in some mixed tribal social and cultural effects due to effects of the alternative on resident fish in certain regions. In particular, in Region A, MO3 may have minor to moderate adverse effects on bull trout and Kootenai River white sturgeon due to food web effects, varial zones, and habitat loss. In contrast, in Region C, MO3 is anticipated to result in long-term benefits for some species of ceremonial and subsistence importance, such as white sturgeon and bull trout.

**SUMMARY OF EFFECTS**

Commercial and ceremonial and subsistence fisheries targeting anadromous fish species across all regions may see major beneficial effects in the long term. Ceremonial and subsistence fisheries targeting residential species in Region C may see long term benefits, while those in Regions A may experience some moderate adverse effects.

### *3.15.3.6 Multiple Objective Alternative 4*

**SOCIAL WELFARE EFFECTS**

The social welfare effects analysis considers the extent to which the effects of the alternatives on fish (as described in Section 3.5) affect the economic value of commercial fisheries.[40,41] MO4 is anticipated to result in minor beneficial effects to anadromous fish species in Regions B, C, and D. In Region B, there may be slight long-term beneficial effects in numerous response metrics for Chinook salmon and steelhead. Under MO4, instream survival of modeled anadromous fish species would increase slightly compared to the No Action Alternative in 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.

benefits under MO4. To the extent that these findings indicate that adult fish abundance will increase, and that commercial harvest increases as a result, benefits to commercial fisheries for these species may occur.

**REGIONAL ECONOMIC IMPACTS**

Because MO4 is likely to result in minor benefits to certain commercially important anadromous fish populations compared to the No Action Alternative, MO4 may result in some increases in regional economic effects of commercial fishing activities if increases in commercial fishing catch occurs.

**OTHER SOCIAL EFFECTS**

**Non-Tribal**

Because MO4 is likely to benefit some commercially important anadromous fish populations compared to the No Action Alternative in Regions B, C, and D, MO4 may result in some beneficial social effects, if the level of commercially caught anadromous fish increases under this alternative.

**Tribal**

MO4 is likely to result overall in minor to moderate benefits to anadromous fish populations of importance in ceremonial and subsistence fisheries compared to the No Action Alternative in Regions B, C, and D. As a result, MO4 may result in some beneficial social effects, if the level of fish caught in tribal ceremonial and subsistence fisheries increases.

However, MO4 may result in minor to major adverse effects on resident fish species of ceremonial and subsistence importance to tribes across all regions. In Region A, increased entrainment and reduced habitat and food availability under MO4 may result in moderate to major adverse effects for species such as bull trout, westslope cutthroat trout, and Kootenai River white sturgeon. In Region B, bull trout, kokanee, rainbow trout, and burbot could experience adverse effects due to increased entrainment risk. In Region C, bull trout and other resident fish may experience adverse effects due to increased gas bubble trauma. Finally, increased TDG and reduced habitat availability may adversely affect resident species in Region D. To the extent that these effects result in decreased catch of resident fish in ceremonial and subsistence fisheries, MO4 has the potential to adversely affect the social and cultural benefits tribes derive from resident fish species through ceremonial and subsistence fishing activities.

**SUMMARY OF EFFECTS**

Because MO4 is likely to result in moderate benefits to anadromous fish populations of importance in commercial and ceremonial and subsistence fisheries compared to the No Action Alternative, MO4 may result in moderate beneficial socioeconomic effects, if the number of fish caught in these fisheries increases. However, moderate to major adverse effects to resident fish species under MO4 may result in moderate to major adverse effects on the value derived from ceremonial and subsistence fisheries for those species.

### 3.15.4 Tribal Interests

As stated in the Affected Environment section and emphasized throughout Section 3.5, fish are of great cultural importance to tribes in the study area and have fundamental roles in diet, medicine, and cultural identity. For virtually all tribes in the region, fish are part of the history of subsistence and important to public health. The CRS dams are viewed by tribes as an impediment to the aquatic resources that are essential to the tribal way of life. For example, the Lower Snake River dams are seen to adversely impact tribes that rely on the Snake River aquatic resources.

Each tribe has a personal, cultural, spiritual and commercial connection with the rivers around them. For instance, the Kootenai Tribe of Idaho and *Yaqan Nukiy*, the main source of subsistence historically was fishing. The Kootenai River itself became part of the Tribe's identity and historically there were a number of camp locations along the River such as at Jennings, Montana. This is similar for all tribes and their connection to their surrounding rivers.

The fish analysis (Section 3.5) evaluates how MOs impact adult and juvenile anadromous and resident fish in the study area. In terms of how that would impact Tribal Interests, the analysis assumes that improved fish conditions would result in more fish available for harvest and, in general, would lead to socioeconomic benefits. As a result of differing environmental conditions based on geographic location, and the relative importance of individual fish species, not all tribes would experience these benefits equally.

In general, however, the analysis describes the following effects.

#### *3.15.4.1 Salmon, Steelhead, and other Anadromous Fish*

- Upper Columbia River salmon and steelhead would see similar or minor increases in juvenile and adult returns for MO1, MO3, and MO4. Tribal members that harvest these populations in ceremonial and subsistence or commercial fisheries may see an increase in numbers of fish return, except under MO2. MO2 would result in decreased abundance for these fish.
- Snake River salmon and steelhead would generally see minor improvements under MO1, although minor adverse effects to sockeye salmon and fall Chinook salmon may occur. MO2 would result in decreases in juvenile survival and adult abundance would also decrease. MO3 would have short-term construction related effects but could lead to long-term increases in adult returns, especially for Snake River Chinook salmon and steelhead. MO4 may result in minor long-term beneficial effects on Chinook salmon and steelhead. Tribes that rely upon these fish species for commercial or ceremonial and subsistence harvest may experience impacts corresponding to the nature and extent of impacts anticipated for these species under each alternative.

#### *3.15.4.2 Resident Fish*

- Region A: MO1 would have minor to moderate adverse effects on bull trout Kootenai River white sturgeon, and burbot. MO3 would have riparian and sturgeon recruitment effects in the Kootenai River as well. MO2 and MO4 would have moderate to major adverse effects in the same areas. Commercial and ceremonial and subsistence fisheries that depend upon these species may be affected if these impacts result in reduced availability of fish for harvest.
- Region B: MO1, MO2, and MO4 would have moderate adverse effects to resident fish in Lake Roosevelt stemming from increased entrainment, varial zone effects (important for migration) and in the river reach, there would be minor reduction in sturgeon recruitment. MO3 would have increased recruitment and connectivity for sturgeon in McNary Reservoir with minor short-term construction-related adverse effects. To the extent that these adverse effects result in fewer resident fish available for harvest, tribal commercial and ceremonial and subsistence fisheries may be affected.
- Region C: MO1, MO2, and MO4 result in adverse effects to resident fish due to warmer summer water temperatures, reduced flows, increased entrainment, or increased TDG and GBT. MO3 would result in long-term benefits for bull trout and white sturgeon. Tribes that harvest these species for commercial and ceremonial and subsistence purposes may see beneficial effects under MO3, but may be adversely affected under other alternatives.
- Region D: Under MO1, resident fish may see minor adverse effects due to warmer summer water temperatures, reduced flows, or increased TDG and potential for gas bubble trauma. MO2 and MO3 pool increases at John Day increases white sturgeon habitat but may increase stranding. Under MO4, increased TDG and reduced habitat availability may adversely affect resident fish species. The tribes that rely upon these species for commercial and ceremonial and subsistence harvest may experience similar effects, should the impacts to fish result in changes in the availability of fish for harvest.

All of these fish have economic, subsistence and cultural importance for tribes, and as shown, effects vary across the study area depending on species.

## 3.16 CULTURAL RESOURCES

### 3.16.1 Introduction and Background

Cultural resources include the entire spectrum of objects and places, from artifacts to cultural landscapes, and will be analyzed here without regard to importance or their eligibility for inclusion in the National Register of Historic Places (NRHP), any state register (such as the Washington Historical Register), or local registers or designations. For the CRSO EIS, cultural resources are grouped into three property-based categories: archaeological sites, TCPs, and historic built resources. Archaeological sites include both precontact and historic-period recorded sites. TCPs are locations of cultural importance to a community, be it a Native American tribe, a local ethnic group, or the people of the nation as a whole. Built historic resources are known buildings, structures, and objects within the study area that are more than 50 years old. Pursuant to Executive Order 13007, the co-lead agencies contacted 19 tribes to request their assistance in identifying sacred sites within the study area, which are evaluated as a cultural resource. Sacred sites have a unique definition in E.O. 13007 based on tribal religious beliefs and practices and are not necessarily associated with archaeological sites nor a result of economic activities. More information on sacred sites is presented in section 3.16.2.7.

Since the 1930s, the co-lead agencies have been working to address the effects of reservoir operations and maintenance on property-based cultural resources. The pace of this work picked up in the 1990s, and since then, the co-lead agencies have worked together to identify cultural resources, evaluate effects, and resolve effects to properties affected by the Columbia River dams. To date, more than 150,000 acres have been inventoried, hundreds of traditional cultural properties (TCPs) have been identified, and multiple built historic resources and over 4,500 archaeological sites have been recorded (FCRPS 2019). This work is currently coordinated and consulted on under the provisions of the *Systemwide Programmatic Agreement for the Management of Historic Properties Affected by the Multipurpose Operations of Fourteen Projects of the Federal Columbia River Power System for Compliance with Section 106 of the National Historic Preservation Act*. More information is available on the FCRPS Cultural Resource Program website at https://www.bpa.gov/efw/CulturalResources/FCRPSCulturalResources/Pages/default.aspx

#### *3.16.1.1 Area of Analysis*

The CRSO cultural resources study area is the area within which effects to cultural resources will be considered. For the CRSO EIS it is defined as the 14 dam and reservoir locations and an area extending 1 mile in all directions from the reservoir full pool elevation to include the tailrace of each dam. It is anticipated that the 1-mile radius from full pool will encompass all effects to cultural resources under each alternative. Having a similar area of analysis surrounding each hydroelectric project will allow for consistent comparison of effects across all 14 projects. Not all lands within the study area, especially permanently inundated and private lands, have been surveyed for cultural resources.

The co-lead agencies have identified 19 federally recognized Native American tribes that ascribe cultural importance to various parts or all of the study area. Broadly, most of them can be grouped into either the Columbia Plateau or Northwest Coast cultural areas. Prior to the arrival of European Americans approximately 250 years ago, it was both these tribal peoples and their ancestors who created the precontact archaeological period sites within the study area. Other peoples and groups with an interest in the cultural resources of the study area include historians, archaeologists, anthropologists, non-federally recognized tribal groups, and other concerned citizens.

## 3.16.2 Affected Environment

### *3.16.2.1 Ethnohistory*

At first, it was the accounts of early explorers like Lewis and Clark (Thwaites 1904; Meinig 1968; Dietrich 1995; Durrenberger 1998), fur traders (Ross 1849; Elliot 1914; Tyrell 1916), and settlers that helped the broader American public become more familiar with tribes and their way of life. Formal ethnographic research accelerated at the turn of the nineteenth to twentieth century and has continued into the present (Ray 1936, 1938; Stern 1998; Walker 1998). Today, many tribes are active in the ethnographic research of their people (Karson 2006; George 2011; Hunn et al. 2015). A generalized summary of tribal lifeways within the study area at the time of contact follows.

#### SETTLEMENT

Each tribe occupied a territory that included their living sites and places and areas used for hunting, fishing, and gathering. Tribal territories and tribal political identities were influenced by subsistence types and patterns, language, and geography. Tribes' territories included waterways, such as the Columbia River and its tributaries. Geography and environmental variety, as well as their particular history, meant that each tribe's territory varied greatly in size and likely overlapped with their neighbors' territories. The tribes adapted to their territory through their knowledge and use of local resources, knowledge passed down through generations. Tribes also adapted to the dynamic environmental patterns on the landscape and participated in management practices to maintain resources. They were a part of an integral relationship between the land and culture. Tribal territories include places of spiritual power, places where religious events took place, and places on the landscape associated with a time before there were people. For a summary of current tribal concerns please see the tribal perspectives section 3.17.

People's movements around their territory to make best use of each area seasonally are known as seasonal rounds. During the winter people generally lived in permanent villages often located near productive fishing locations. They hunted and gathered resources as available during the winter season, but it was primarily a time for community and ceremonial gatherings, storytelling, and intergenerational sharing of knowledge. From spring through fall, smaller family groups traveled away from the winter village and built temporary structures such as mat lodges at short-term occupation locations where there were plentiful plant, fish, and game resources. They also gathered items, such as wood and stone, and traded with others during these seasonal rounds. This is also the time people went to larger rivers to fish for anadromous fish, like steelhead and salmon, as they swam upstream to spawn. In addition, root plants were gathered and prepared for overwintering (Walker and Sprague 1998; Historical Research Associates, Inc. 2015).

Euroamerican explorers like Lewis and Clark or David Thompson who passed through the Dalles and Kettle Falls during the early 1800s saw large intertribal gatherings at these important fishing sites. These gatherings had extended back in time for hundreds, even thousands, of years as people came together to harvest salmon, trade, and interact with peoples from throughout the region. Even though all Columbia Plateau groups relied on similar substantive resources, there were sufficient regional variations to make trade within the Columbia Plateau both desirable and necessary. In addition to trade within the Columbia Plateau there was interregional trade that added to the variety of goods used in the region. Traditional trading partnerships were reinforced by systematic intermarriage, travel by horse, regular trade fairs, and regional economic specialization. This traditional system of trade formed the basis for the later fur trade, which enriched an already established system (Stern 1993; Walker and Sprague 1998).

The seasonal round pattern resulted in a variety of archaeological site types, TCPs, and material assemblages present within the study area. Site types considered in the analysis of this EIS are presented in Section 3.16.2.2, *Archaeological Site Types*.

**SUBSISTENCE**

For much of the Columbia River Basin region, the various predictable and abundant runs of salmon, steelhead, and bull trout made up the bulk of protein in people's diets. But since this particular resource declines in both nutritional value and availability as distance from the ocean increases, variation in its dietary importance did exist (Historical Research Associates, Inc. 2015). Not coincidentally, the importance of ungulates, such as deer, antelope, and elk, in the diet increased with the declining availability of salmon. Fishing was a predictable source of food, with annual variations in the quantity of fish available. Hunting, however, was not as reliable as a hunter may invest considerable time searching for prey with an unpredictable return for the effort (Hayden and Mathewes 2009; see also Patterson et al. 2005; Hay et al. 2007).

Fishing occurred throughout the Columbia River region, but larger groups of people from different regions gathered annually at specific areas of abundance (e.g., Celilo Falls, Kettle Falls) to harvest and trade. The timing of the runs of anadromous fish was carefully tracked so groups of people could be sent to harvest and process large numbers of fish at the migratory choke points. The productivity of some fisheries was so great that it provided both for residents' needs and those of visiting communities. Such co-exploitation by multiple groups at these rich resource sites provided an opportunity for intergroup exchange. Such exchanges were not limited to the trading of material objects, but included interband marriage, sporting competitions, development and continuation of commercial relationships, forging alliances among distant communities, and dissemination of skills and knowledge among communities.

In addition to fishing and hunting, many tribes relied on plants found in various environments. Bulbs, roots, and corms such as camas, lomatia, bitterroot, and wapato not only provided the principal source of carbohydrates, dietary fiber, and the bulk of calories in traditional diets, but were the most reliable resource that could be attained in large quantities (Hunn 1990). Added to these food resources were various flowering fruits (e.g., huckleberry, serviceberry, chokeberry) and nuts that people consumed both in season and as overwinter provisions.

**HABITATION AND MATERIAL CULTURE**

For at least the last 5,000 years, there have been permanent winter villages and temporary resource gathering short-term occupation locations in the Columbia River Basin. The winter villages usually had semi-subterranean earthen lodges or pithouses along main rivers. The oblong lodges varied in depth and diameter depending on the number of people living in them. Winter villages also had associated special-purpose use sites such as cemeteries, food caches, and specialty work areas. Resource gathering short-term occupation locations had mat-covered lodges at higher elevations, located near specific resources (Walker 1998; Historical Research Associates, Inc. 2015).

Intermixed within the residential structures were work areas for manufacturing and maintaining tools for family needs and wants. Archaeological investigations of sites that date from the late precontact period and into early historic times have documented changes in the tool collections of residential sites, harvest areas, and quarry locations. Changes had begun before Meriwether Lewis and William Clark's visit to the region in 1805, but increased substantially as European American traders moved into the region. The Hudson's Bay Company brought many changes to Columbia Plateau culture (Historical Research Associates, Inc. 2015). Their traders introduced metal knives, guns, manufactured clothes and blankets, new forms of fishhooks and nets, new paints and dyes, traps, and jewelry that were adopted and adapted into Native households. Houses also shifted from large multi-family dwellings to smaller single-family ones typical of European Americans (Walker and Sprague 1998, 144; Historical Research Associates, Inc. 2015).

### *3.16.2.2 Archaeological Resource Types*

For the purposes of the CRSO EIS there are 18 archaeological resource types that will be examined. These site types encompass both precontact and historic-period sites, including ruins of built resources. Site types and descriptions follow in Table 3-286. Table 3-287 shows if the site types are present in the study area, by project, and includes both sites on dry land and those that are inundated. Single archaeological resources may represent an event, occupation or activity; groupings of sites can form an archaeological district that is linked by a geographic boundary, time, or a common theme.

**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. |

1/ A dendroglyph is an image or design carved into the bark of a tree.

**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 | Dworshak | 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 | – |

### *3.16.2.3 Precontact*

The archaeological record of the Columbia Basin spans a period of about 13,000 years. There is no single cultural chronology, or identified timeline of events or period and occurrences of site types, of the basin as a whole. Rather chronologies have been developed for specific research purposes for particular sites, reservoirs, or subdrainages. The information presented below is a generalized chronology of the prehistory of the Columbia Plateau, and it will differ slightly with each specific location. For additional information and description of the precontact period, please see Browman and Munsell (1969); Reid (1995); Ames and Dumond (1998); Ames et al. (1998); Chatters and Pokotylo (1998); Pokotylo and Mitchell (1998); Roll and Hackenberger (1998); Andrefsky (2004); Prentiss et al. (2005); Pouley (2008); Davis, Willis, and Mcfarlin (2012); and Lyman (2013). Archaeological sites from all the periods described below have been found within the study area.

**EARLY PERIOD, 9000 TO 6000 B.C.**

People of the Early Period were highly mobile foragers, lived in small groups, and subsisted on a variety of seasonal foods. In the Southern Plateau, salmon was plentiful, but in the Northern Plateau people relied more on large fauna. People lived in small, short-term occupation locations that were moved frequently. Evidence from the middle Columbia region shows conical-shaped, tipi-like structures were used. There is also evidence of the use of windbreaks and huts (Binford 1980; Chatters 1986; Ames 1988; Ames et al. 1998; Chatters and Pokotylo 1998).

Stone tools during this period included project points, specifically dart points or spear tips, with wide bases relative to blade size. Some show edge grinding of the stems, the area of the point near the base. These points would have been used on the ends of spears for thrusting or darts for throwing at game using a dart-thrower called an atlatl. The blade shapes and sizes were highly variable because of resharpening and reuse. Early Period sites consistently had assemblages of scrapers, for cleaning hides, and flake tools quickly made from stone flakes without much further modification. In the Southern Plateau small milling stones, manos, and edge-ground cobbles have been found, indicating the plants were being ground. Artifact collections also include weighted nets, harpoons, bolas (a weapon with stones tied to multiple cords), and delicate bone needles indicating the use of tailored leather clothing (Ames et al. 1998; Chatters and Pokotylos 1998).

**MIDDLE PERIOD, 6000 TO 2000 B.C.**

The Middle Period started very similar to the previous Early Period, with people living in small, mobile, short-term occupations. They hunted and fished, but also started to really use roots, such as camas, which is evident from the increased number of earth ovens found at archaeological sites. New styles of projectile points were also introduced, possibly from the migration of people from outside the Plateau. People relied more upon salmon and other marine species, making up about 40 percent of their diet, with animal hunting and plant gathering making up the remainder. As the Middle Period progressed, people started to live a less mobile lifestyle. Small hamlets of one to three pithouses, living structures partially dug below surface ground level, appeared. Along with a more sedentary lifestyle came a decrease in seasonal field short-term occupation locations and an increase in storage pits at sites, showing use of a more diversified diet that was readily available near main habitation short-term occupation locations. There was also an increase in trade for obsidian and exotic materials used to make stone tools, pipes, and beads (Ames et al. 1998; Chatters and Pokotylos 1998).

**LATE PERIOD, 2000 B.C. TO A.D. 1720**

By 2000 B.C., the shift from a mobile forager lifestyle to a storage dependent and sedentary collector strategy was well underway. Decreased temperatures brought an abundance of salmon to the rivers and an increased reliance on marine resources. Up to 50 percent of the diet was from marine resources, but there was also an increase in the use of roots, with large root processing earthen ovens and large mortars being used at sites. Temporary short-term occupation locations in river valleys were used for fish, game, root, and mussel acquisition. Large settlements, with upward of 100 pithouses, have been found along the lower reaches of rivers. The houses themselves tended to be smaller than in previous time periods, with an intensification of storage and salmon processing areas. A greater variety of stone tools were used, bow and arrow technology appeared in this area, and portable art and trade goods, including shells, beads, steatite pipes, clubs, and elaborately carved implements and ornaments of stone, whalebone, and antler increased. Rock art began to appear, possibly to identify band territories or serve other functions. There is also direct and indirect evidence of intergroup conflicts, with the fortification of mesas and the presence of sites and storage facilities in highly defensible locations. Social inequality is evident in the varied house sizes as well as the variety of exotic goods. This inequality probably created or amplified the demand for exotic goods and art objects (Ames et al 1998; Chatters and Pokotylos 1998).

### *3.16.2.4 Historic Period*

The historic period began with the introduction of European American influences with the first contact of non–Native American people. The impact of the horse, epidemic diseases, trade goods, missionaries, and fur traders was felt throughout the Columbia River Basin.

For additional information and description of the historic period please see Historical Research Associates, Inc. (2015), or Walker (1998).

**EURO-AMERICAN EXPLORATION**

In May 1792, Robert Gray became the first European American to record seeing the mouth of the Columbia River. Non-Native use of the mouth of the Columbia rapidly accelerated after this, and by 1800, over 100 ships had entered the mouth to trade with Native inhabitants. In 1805 the Corps of Discovery (also known as the Lewis and Clark Expedition) reached the Columbia River estuary. The route of the Corps of Discovery took them through the present-day locations of the Dworshak, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, John Day, The Dalles, and Bonneville dam and reservoir projects and provides some of the earliest written accounts and maps of the study area. As the first U.S. Government–sponsored cross-continent expedition, the Corps of Discovery traveled with three related goals: exploration, trade, and the formation of political alliances with Native American groups. The journals of Lewis and Clark record the geography and environment through which the Corps of Discovery traveled, as well as their observations and interactions with various Native Americans encountered during their journey. The Corps of Discovery reached the Snake River in October 1805 and first saw the Columbia River on October 16 of that year. They traveled down the Columbia and established their winter camp at Fort Clatsop near the mouth of the Columbia River. After wintering, they traveled back up the Columbia River on their way back to St. Louis (Meinig 1968; Moulton 1988; White 1991; Beckham 1995; Dietrich 1995; Schwantes 1996; Durrenberger 1998; Rochester 2003).

The explorers, as well as the settlers who followed, brought new trade goods and horses, and introduced new diseases, such as smallpox, measles, and influenza. The Native Americans had not been previously exposed to these diseases and did not have natural immunity or ways to treat them. Given this, the diseases had a devastating effect on the population (Beckham 1995; Walker and Sprague 1998).

**FUR TRADE**

The fur trade dominated the non-Native economy of the Columbia River Basin for the first half of the nineteenth century. It owes its rapid growth, in part, to its integration with the already functioning traditional Native American trade system that linked people throughout the American West. Trade centers, such as The Dalles and Kettle Falls, saw large intertribal gatherings. This traditional system of trade formed the basis for the fur trade (Beckham 1995).

Manufactured goods brought by the fur traders were frequently embraced by Native Americans. The fur traders introduced glass beads, woolen blankets, metal tools, firearms, cotton cloth, and other items that the Native Americans modified or adapted to be useful in new ways. In exchange European Americans purchased furs from the Native Americans (Beckham 1995; Walker and Sprague 1998).

Two British companies, the Northwest Company and the Hudson's Bay Company, competed to control the fur trade throughout the British territory in North America. Kootenay House, Flathead House, Spokane House, and Fort Nez Perce were established by the Northwest Company and Fort Colville and Fort Boise was established by the Hudson's Bay Company in the region. The Northwest Company controlled the trade in the Columbia River Basin until it merged with the Hudson's Bay Company in 1821. With the merger, the Hudson's Bay Company inherited Flathead House, Spokane House, and Fort Nez Perce. The Hudson's Bay Company entered into new ventures as beaver pelts lost economic value. These included the production of grain, livestock husbandry, commercial logging, blacksmithing, and mining. By the 1840s the Hudson's Bay Company had moved northward and abandoned its Columbia River holdings (Simpson 1847; Caywood 1967; Meinig 1968; Ross 1975; Emerson 1994; Dietrich 1995; Walker and Sprague 1998; Lang 2015).

**MISSIONARIES**

While the fur trade and exploration brought changes to the clothing, technology, and trade of the Native Americans in the region, the advent of Christian missions ultimately had a larger impact. The missionaries' impacts were not so much in the changing of Native religious practices, as much as bringing the European American settlement and lifeways to the region (Beckham 1995). Missionaries played an important role in the settlement of the Pacific Northwest by bringing European Americans to the region, but also because they lived alongside the Native Americans. In addition to the missionaries coming to the region and establishing missions, there were delegations of Native Americans who went east to learn Christian and European American ways (Walker and Sprague 1998). The remains of some of the missions are within the study area, but the impacts of the missionaries are much farther reaching.

In 1834, Methodist minister Jason Lee set out for the Columbia River with a party of four American men and fur trader Nathanial Wyeth. Upon reaching Fort Vancouver, Lee decided to establish a mission in the Willamette River valley. He later established a mission near Five Mile Rapids and Celilo Falls. From the Wascopam Mission, Lee and various other ministers labored to preach the work of God, but also practiced agriculture, planted a large garden, and introduced cattle to the area. Other missionaries who established missions included the Whitmans at Waiilatpu on the Walla Walla River, the Spaldings near Lapwai on the Clearwater River, and Mengarini and Point who established the Sacred Heart Mission among the Coeur d'Alenes and St. Mary's Mission in the Bitterroot Valley of Montana (Beckham 1995; Dietrich 1995; Schwantes 1996).

As time went on, missionaries increasingly focused on promoting European American settlement in the territory over converting Native Americans to Christianity. They wanted the tribes to embrace a more European American lifestyle, primarily by practicing agriculture, especially grains and fruit trees, and livestock husbandry (Beckham 1995). While there were some positive aspects of these interactions between missionaries and tribes, it is also important to note that missionaries sometimes contributed inadvertently to the spread of European diseases to which few Native Americans had immunity. Estimates of the Native American depopulation due to disease range as high as 60 to 90 percent (Campbell 1989).

**TREATIES**

The Organic Act of 1848 established the Oregon Territory and the Organic Act of 1853 created the Washington Territory. Governor Stevens was the new governor of the Washington Territory and the Superintendent of Indian Affairs for the region. His goals for Indian administration included securing treaties with the tribes, reserving a few tracts of good land for the tribes, fostering an agricultural program, and encouraging amalgamation of small bands under a few chiefs on the reservations. Governor Stevens launched his treaty program in 1854 in western Washington, then moved east of the Cascades in June 1855, where he was joined by Joel Palmer, Superintendent of the Oregon Territory. Stevens pressed for agreements with the local tribes and negotiated three separate treaties in Walla Walla in June 1855; one treaty with the Cayuse, Umatilla, and Walla Walla; a second treaty with the Nez Perce Tribe, and a third treaty with the and Yakama Tribes. The Treaty of Hellgate was negotiated in July 1855 with Bitterroot Salish, Pend d'Oreille, and Kootenai Tribes. Palmer negotiated the Treaty of 1855 with the Wasco (Warm Springs). The treaties ceded lands, created reservations, provided for agricultural and educational programs, reserved fishing rights, and protected hunting, gathering, and grazing rights. None of the tribes to the north of Yakima in central Washington and northern Idaho participated in the treaties with the United States. Additional reservations in the study area were formed by executive orders. Some of these executive orders retained tribal rights similar to the treaties, while others were more restrictive (Ruby and Brown 1972; Beckham 1995, 1998; Walker and Sprague 1998; Confederated Salish and Kootenai Tribes of the Flathead Reservation 2019; Confederated Tribes of the Warm Springs 2019).

The treaty program thus provided an incomplete settlement with the tribes of the Columbia River Basin. Some tribes and bands secured ratified treaties with specific reserved rights. Others participated in councils but never secured ratification of their agreements. Still other tribes and bands remained outside of the treaty process altogether. These inconsistencies, the continued trespass of European American settlers, and the influx of miners and cattle drovers set the stage for the Indian Wars, which beset these people in the middle of the nineteenth century (Beckham 1995).

**SETTLEMENT**

In 1843, missionary Marcus Whitman led 1,000 Americans along the Oregon Trail, in what became known as the Great Migration. The overland route effectively ended at The Dalles, where the pioneers would raft down the Columbia River to Fort Vancouver and into the Willamette Valley (Dietrich 1995; Schwantes 1996). Within a few years the number of immigrants arriving tripled to about 3,000 per year (Beckham 1995). In 1849, the War Department dispatched the Overland Rifleman, a contingent of the U.S. Cavalry, to cross the Oregon Trail and establish military posts to ensure peaceful relationships between Native Americans and settlers (Beckham 1995).

Towns were established near existing army posts as well as in other rural areas. They were often arranged linearly up streams and creek beds in the best agricultural land and were densely settled. Beyond the prime agricultural plots, more thinly occupied regions developed (Meinig 1968). The U.S. Government actively encourage westward migration of European Americans through a series of land settlement acts passed by the Congress. The Donation Land Claim Act of 1850 lead to the early European American settlement of the Oregon Territory, which included modern day Washington State, with the promise of 160 acres of free land to settlers. Many prime pieces of land in the Columbia Gorge and elsewhere in the study area were settled under the act (Beckham 1995; Riddle 2010). The Indian Treaty Act of 1851 authorized the use of funds to negotiate treaties with Indian tribes and bands. The intent was to settle potential claims by Indians to the land through the treaties (Bennett 2008).

In 1862, Congress passed the Homestead Act, that allowed any citizen or alien who declared their intention of becoming a citizen, and who was head of a family and over 21 to claim 160 acres of land from the surveyed portion of the public domain. This also meant women, many of whom were widowed during the Civil War, were eligible for tracts of land. In 1880, Congress extended the act to include portions of the public domain yet to be surveyed. After residing on this land, adding improvements, and paying a small registration fee, homesteaders would become the owner (Bruce 2001). Between 1862 and 1890, 372,659 homesteads were claimed through the Homestead Act. By 1940, homesteads occupied 285 million acres of formerly public land (Gilbert 1968; Bruce 2001; White 1991). Within the study area, the remains of these homesteads can be seen as buildings, foundations, gardens, and irrigation ditches and other archaeological features.

**U.S. GOVERNMENT AND SETTLEMENT IMPACTS TO TRIBES**

The complex history of U.S. Government policies and settlement had varied, profound, and long-lasting effects on every aspect of tribal life. Before Euro-American settlers arrived in the region, their presence on the North American continent entailed the arrival in the Pacific Northwest of European diseases against which the native people had no immunity. There is some archaeological evidence to indicate that epidemic diseases may have arrived in the region as early as the 1500s or 1600s after the Spanish came into the American Southwest (Campbell 1989). During the 1770s, outbreaks of small pox are believed to have killed potentially as much as 30 percent of the tribal population in the Pacific Northwest (Boyd 1994). By the time Lewis and Clark traveled the Columbia, it was estimated that two different outbreaks of western disease had decimated the people living along the Columbia River.

The Spanish exploration of the Northwest Coast may have begun as early as the 1540s. In 1707 the first well documented contact occurred with the wreckage of the Spanish galleon San Francisco Xavier, on the Oregon coast after being blown off course. The Spanish, Russian, and English did not reach the area to intentionally explore it until the early 1770s. European contacts at the coast spread disease rapidly inland and disease claimed whole villages. During the 80-year period from the 1770s to 1850, smallpox, measles, influenza, and other diseases swept through the region. Epidemics of smallpox appeared every generation: in the late 1770s, 1801-02, 1836-38, and finally (in two separate areas) in 1853 and 1862-63. While a precise number of people who succumbed to these diseases will never be known, it is accepted that 60 to 90 percent of the tribal population was lost to these diseases (Boyd. 1994).

Concurrent with the outbreaks of diseases, increasing numbers of non-tribal settlers began to arrive in the region from the 1840s onwards. Before then, contact between the tribes and non-tribal peoples was limited to fur traders and explorers. Starting in the 1840s, the establishment of improved and expanded trails saw an influx of non-tribal settlers, who were encouraged to enter the region by federal policies that promised land to them. In particular, the 1850 Donation Land Claim Act (9 Stat. 496) opened the Oregon Territory, which encompassed almost the entire Pacific Northwest, to settlement even before treaties with the tribes had addressed Indian ownership of the land.

While relations between tribal and non-tribal peoples were mostly peaceful, the increasing numbers of settlers resulted in growing tensions in the 1850s as tribal people found themselves cut-off from traditional gathering areas, hunting grounds, and village sites, as well as increasing competition for the region's abundant, but nonetheless, limited resources. These conflicts prompted the U.S. Government to enter treaty negotiations with many of the tribes. These negotiations resulted in arrangements through which the tribes ceded large portions of land to the U.S. Government in return for smaller areas of reserved land and promises of food, healthcare, education, and tribal governance, among other provisions. After 1871, reservations were formed by Executive Order. While the reservations were sometimes located on the ancestral lands of the tribes to whom they were assigned, often the tribes were forced to abandon their traditional areas and relocate to areas that they had no, or limited connections to. This relocation severed cultural connections with traditional use areas for food and root gathering, hunting, habitation, burial, spiritual, and meeting.

The treaties were not entirely successful in resolving the tensions that originally prompted the U.S. Government to start negotiations. In many cases, the terms were unacceptable to some of the tribes. In other instances, while treaties were signed, they were never ratified by Congress. Tension rose in the region due to differences in treaty interpretation, U.S. Government failure to abide by commitments, and non-tribal population growth. These unresolved tensions resulted in armed conflict beginning in the mid-1850s between some of the region's tribes and non-tribal settlers supported by local militias and the U.S. Army. In the Pacific Northwest, these battles culminated in the Nez Perce War in 1877, which involved Chief Joseph's famous fighting retreat toward Canada.

The establishment of the reservations did not end the pressure brought by non-tribal settlers seeking access to tribal land. In 1887, Congress passed the General Allotment Act, also known as the Dawes Act (24 Stat. 388). This measure, conceived as a means of parceling out reservation lands to individual tribal members and to be held in trust by the U.S. Government, had the effect of significantly reducing the amount of land held by tribes. Tribal lands not allotted to tribal members on the reservation were sold by the U.S. Government to homesteaders. When the allotment process began in 1887, the total reservation land held by tribes equaled 138,000,000 acres. By the end of the allotment period, tribal landholdings were dramatically decreased to about 48,000,000 acres (DeLoria and Salisbury 2004). This policy resulted in the 'checker-boarding' of reservation land. Land ownership within reservations was a mix of a larger number of fee-owned private properties, the majority of which were non-tribal owners, and fewer properties held in tribal trust.

**MINING**

Two major mining rushes occurred in proximity to the study area during the second half of the nineteenth century: the Colville gold rush (1855) and the Clearwater gold rush (1861). After Hudson's Bay Company employees found placer gold near Fort Colvile in 1855, hundreds of miners rushed to the upper Columbia River region. The Colville gold rush was relatively short lived and did not produce a substantial amount of wealth (Tate 2004). In the early 1860s, a gold rush along the Clearwater River brought prospectors to goldfields that extended from Walla Walla to the confluence of the Clearwater and Snake Rivers (Lundin and Lundin 2012). The Clearwater gold rush produced wealth that shaped settlement in the Columbia River Basin from the 1860s up to the present. Communities boomed in Lewiston, Pierce City, Orofino, and Walla Walla as thousands of prospective miners traveled to the Clearwater River. By the mid-1860s, the Clearwater gold rush had run its course. A few of the newly established communities stabilized and endured as permanent settlements, others were abandoned. The Clearwater gold rush directly contributed to the reduction of the Nez Perce Reservation from its original 1855 size of about 7.5 million acres to the post–gold rush size of about 750,000 acres as miners pushed the government for greater access to reservation lands (Walker 1998). Other mining took place in the Blue Mountains of Oregon where gold was discovered in 1861, a few miles to the southwest of Baker City. When the placer mines declined, the quartz mining industry developed in the late 1860s and slowly evolved until another gold and silver boom occurred in 1899. With this new boom came the development of Baker City as a supply point, the flourishing of mining towns such as Union and Huntington, and the revival of Sumpter, Oregon. There was gold mining in many other locations, such as in Hells Canyon and along the Salmon River. In some cases, even gold rushes outside of the Columbia River Basin had an impact on the study area. For example, a gold rush occurred in the Fraser River Canyon in the late 1850s. To help feed the booming population of miners, ranchers drove cattle up the "Cariboo Trail" from Wallula Gap near the confluence of the Snake and Columbia Rivers to the mouth of the Okanogan River and then up to Canada (Dorpat and McCoy 1998). Miners who traveled these routes sometimes came into conflict with tribes, who had not authorized the heavy use and related depredation of these traditional travel corridors. The McLoughlin Canyon skirmish of 1858 is a well-known example of this kind of conflict in the region (CTCR 2006). Additionally, there was copper and iron mining in the vicinity of the Albeni Falls dam and reservoir project (Meinig 1968; Schwantes 1996; Tate 2004; Lundin and Lundin 2012).

In addition to the gold rushes, there were placer mines up and down the Columbia, Snake, and Pend Oreille Rivers. Many of the mines were run by the Six Chinese Companies, which employed Chinese people from the Cantonese countryside who would send money back home (Evenson 2016). They established large placer mining camps at places such as Marcus and China Bend along the upper Columbia River. There were also a handful of Chinese owned and operated merchant stores along the Columbia River and its tributaries. Many of the settlements, placer mining sites, and the stores that provided supplies have been inundated. Some remnants of these are now archaeological sites located within the study area, primarily near the edge of reservoirs.

**AGRICULTURE**

Agriculture and herding within the region were important parts of the economy. Practiced by Hudson's Bay Company employees, missionaries, and some Native American groups in the region, herding spread throughout the basin in the early 1860s. Cattle and sheep were the major species in the region, though people also raised horses, mules, burros, and hogs. The cattle industry boomed along with the mines in the mid-1860s, then leveled out as the Clearwater gold rush tapered off and the mining communities raised their own herds in valleys adjacent to the mines. Exporting to new markets around Puget Sound and in the East, the cattle industry peaked during the 1870s before being replaced by smaller ranches during the 1880s (Meinig 1968).

The Hudson's Bay Company introduced subsistence farming to the Pacific Northwest in the 1820s, as the company sought to increase the self-sufficiency of their trading posts. Missionaries and settlers arriving in the 1830s also brought agricultural methods and cultivars with them, planting orchards, gardens, and grain on early homesteads along the river valleys. Similar to the livestock industry, farmers responded to the booming demand for oats and wheat during the Clearwater gold rush. The early 1860s were marked by increased production of wheat throughout the Columbia River Basin and agricultural experiments to determine the optimal planting and growing conditions for the crop. By 1870, agriculture, predominantly wheat, had become the primary industry in the Columbia River Basin. The construction of railroads across the region (primarily in the 1880s) furthered industrial growth. The railroads attracted new settlers and opened up additional routes through which they could export products to distant markets (Meinig 1968; Pfaff 2002).

**LOGGING**

As with the other major historic-period industries, the Hudson's Bay Company was the first entity in the Pacific Northwest to conduct commercial logging operations in the Columbia River Basin. Commercial exports of timber began in 1848 when a mill was established in Oregon City. By 1850, 37 sawmills had been established in the Pacific Northwest, most near the mouths of the Columbia and Willamette Rivers. The industry dominated the region during the second half of the nineteenth century and through the first half of the twentieth century. The remnants of historic-period logging activities exist today as archaeological sites within several locations of the study area. These types of sites are mostly located under storage reservoirs in higher elevation or mountainous terrain such as near Hungry Horse or Libby dam and reservoir projects. For further information on the history of logging and potential related resources see Holbrook (1990); Historical Research Associates, Inc. (2016); and Harrison (2008c).

**FISHING**

Salmon fishing has been important to the Native American diet and formed an integral part of their lives for at least 10,000 years (Hunn and French 1998; Butler and O'Connor 2004). Sturgeon and lamprey have also been important to the Native Americans of the area. In the historic period, tribes continued to fish at important locations, such as Kettle Falls and Celilo Falls as well as other lesser known fishing locations. They established seasonal habitation areas in these locations and built fishing platforms to make it easier to fish at the falls and rapids. Remains of these camps can still be found in the archaeological record (Anastasio 1972; Beckam 1998; Hunn and French 1998).

At its peak, fishing was the second largest industry in the Washington and Oregon Territories, behind the timber industry. The Hudson's Bay Company shipped barrels of salmon to London in 1827, the first recorded fish exported from the Columbia River Basin. Missionaries and other settlers joined the salt-salmon trade, but they struggled to find ways to store and preserve the fish being transported to Hawaiian, British, and other distant markets. As methods improved, salt-salmon fisheries continued to operate in the Columbia River Basin through the 1880s (Smith 1979; Schwantes 1996). The first salmon cannery was established on the Columbia River in 1866 and by 1883 there were 43 canneries operating on the river. The last major cannery shut down in 1980. The commercial canning industry used many methods to catch the salmon runs, but none were as effective as the fish wheel, which was introduced in 1884. By 1899, there were 76 fish wheels operating on the Columbia River. Remains of canneries and fish wheels can be found along the Columbia River (Smith 1979; Petersen and Reed 1994; Harrison 2011; Barber 2018).

#### *3.16.2.5 Built Environment*

**HYDROELECTRICITY DEVELOPMENT**

Hydroelectricity production was studied early in the 1900s (Harza 1914), and began on the Columbia River in the 1930s. Today, 49 federal and non-federal hydroelectric dams exist in the Columbia River Basin (FCRPS 2016). In the early 1920s, the Corps River Basin Survey team surveyed the Columbia River Basin and devised a plan that would develop the resource potential of the river along multiple fronts: navigation, flood control (now referred to as flood risk management), irrigation, and hydroelectric power. The River Basin Survey report laid out a plan for the construction of 10 multipurpose dams in the Columbia River Basin. President Franklin D. Roosevelt's administration requested and Congress approved funding for construction of both the Bonneville Lock and Dam and the Grand Coulee Dam in 1933 as part of the New Deal, putting thousands of unemployed Americans to work during the Great Depression. Construction of Bonneville Lock and Dam was completed in 1938. The Grand Coulee Dam, the largest concrete structure in the world at the time, was completed in 1941 (Bonneville ca. 1980; White 1991; Dietrich 1995).

The principal structures within the study area are the series of Federal dams built and put in service between 1938 and 1976. Associated structures, such as transmission lines, substations, and administrative buildings, can be found near the hydroelectric projects. Some of the structures have not yet reached the 50-year benchmark for consideration as a historic built environment resource in this section; however, they are eligible for the NRHP as components of the large-scale Federal civil works undertaking that transformed the Pacific Northwest. Bonneville Dam has been designated a National Historic Landmark. For a description of the dams please refer to FCRPS (2016).

**COLUMBIA AND SNAKE RIVER TRANSPORTATION**

Before the nineteenth century travel along the Columbia River was constrained by the river's fast waters and falls. During the latter half of the nineteenth century, a need to transport mining and agricultural goods emerged. Steamboats were used to transport goods up and down the Columbia and Snake Rivers between ports, but at areas of rapids and falls, such as Celilo Falls and Cascade Rapids, goods had to be offloaded and portaged by foot, wagon, or train. However in 1896 the Cascade Canal opened, which allowed boats to traverse the area of Cascade Rapids without the need to offload and portage. In 1915 the Dalles-Celilo Canal opened, allowing similar access in the area of Celilo Falls (Paulus 2010). With the construction of the various dams and the inundation of lands, roads and railroad beds had to be relocated with the old ones being abandoned in place in many cases. The remains of the locks, roads, and railroad beds still lie in or near the reservoirs (Paulus 2010).

**TRANSPORTATION**

Historic-period occupation and industry in the Columbia River Basin were inseparably linked to advances in transportation. A network of trails used by Native Americans was already in existence when the European Americans arrived. These routes, and new ones, were used by the fur traders and missionaries, laying the way for the Oregon Trail along the south bank of the Columbia River to The Dalles. Migrants then rafted the river from The Dalles to Fort Vancouver and the Willamette Valley. The steamboat era took off during the 1850s and 1860s, as European Americans settled throughout the Columbia River Basin, requiring transportation for themselves and their commercial exports (gold, wheat, timber). While steamboats provided transportation along the river, entrepreneurs established and operated ferry crossings to carry people and goods across the rivers. Remnants of these steamboat and ferry landings still remain within the study area (Ruby and Brown 1974; Dietrich 1995; Schwantes 1996; Harrison 2008b).

Railroads in the Columbia River Basin were initially designed to facilitate transit around dangerous rapids on the lower Columbia River. The first railroad, constructed in 1851, consisted of a portage tramway around the Cascades Rapids, in the present-day vicinity of Bonneville Dam. By 1862, railroad portages operated on both sides of the Cascades Rapids. In 1853, the U.S. Army launched a comprehensive examination of the Pacific Northwest as part of the Pacific Railroads Survey. The purpose of the surveys was to find five alternative routes to bring the railroad to the Pacific Northwest. The surveys were multi-faceted, involving naturalists, geologists, ethnographers, and cartographers. Critical to the location of transportation corridors were the engineers who examined the countryside for grades, curves, tunnels, bridges, and the technical feasibility of the routes. The Northern Pacific line through the Columbia River Basin was completed in 1883 and included the construction of the first bridge across the Snake River, near Pasco, Washington (Meinig 1968; Holbrook 1990; Beckham 1995; Holstine and Hobbs 2005; Harrison 2008a).

Similar to the railroads, the first wagon road in the region was constructed around the portage of the Cascades Rapids (Bullard 1982). Other wagon roads were established in the 1830s and 1840s, but it wasn’t until 1843 that the first wagons on the Oregon Trail reached Oregon. In that year an estimated 900 men women, and children and about 3,000 head of livestock crossed the Oregon Trail (Beckham 1995; NPS 2019b). In 1907, the first public road bridge was constructed across the Columbia River near Wenatchee, Washington. The rise of the automobile in the early twentieth century fueled the construction of county roads and state and interstate highways, as well as a series of related bridges, in the Columbia River Basin throughout the century. Some of these original railroad beds, roads, and bridges still remain within the study area (Meinig 1968; Holbrook 1990; Beckham 1995; Holstine and Hobbs 2005).

**URBAN DEVELOPMENT**

Along with the development of the waterways as shipping canals and the various forms of transportation, urban areas also developed. Along the rivers of the Columbia River Basin steamboat landings of the 1800s and early 1900s turned into cities as these early ports became more established. Many of the early cities, such as Hood River, were dependent on resource extraction, such as logging the forests along both shores of the Columbia River. Built resources related to urban development may include a variety of residential and commercial buildings and structures located within the boundaries of established municipalities, towns, and cities within the study area.

**IRRIGATION**

Irrigation of crops along the Columbia River began with the first permanent settlements along the river. In 1818, Donald McKenzie of the Northwest Company constructed one of the first, if not the first, irrigation systems along the Columbia River at the confluence of the Columbia and Walla Walla Rivers. The system irrigated the gardens of Fort Nez Perce via ditches from the Walla Walla River. When Marcus Whitman arrived in the area 18 years later, he created the irrigation system to water the gardens at his Wailatpu mission, approximately 7 miles west of present day Walla Walla. Other missionaries and forts also created irrigation systems to water their gardens around the same time (NW Council 2019b).

The first large-scale irrigation project in the Columbia River Basin was built in 1859 in the Walla Walla River valley. Private irrigation companies were responsible for watering approximately 2.3 million acres in the region by 1910. Social and economic conditions in the United States during the Great Depression led to a new era of farming and irrigation in the Columbia River Basin. Small homesteads gave way to larger agricultural ventures, financed by outside investors. Irrigation projects that were considered too expensive before World War I, such as the Columbia Basin Project and Grand Coulee Dam, were constructed. From small- to large-scale projects, the irrigation development was an important part of the development of the Columbia River Basin and portions of these irrigation projects can still be seen today in the study area (Meinig 1968; Dietrich 1995; Pfaff 2002; National Research Council 2004). Table 3-288 shows the built resources by type present in the study area, by project.

**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 |

#### *3.16.2.6 Traditional Cultural Properties*

TCPs are a type of cultural resources property that is based on its cultural importance to a living community. A TCP can be defined generally as one that is important because of its association with cultural practices or beliefs of a living community that (1) are rooted in that community's history, and (2) are important in maintaining the continuing cultural identity of the community (Parker and King 1990). The traditional cultural importance of a property, then, is importance derived from the role the property plays in the community's historically rooted beliefs, customs, and practices. While a TCP must be a tangible property, a culturally recognized natural landscape or a natural object, such as a rock outcrop, it may be included if it is associated with a current tradition or use (NPS 1990; Parker and King 1990).

For this EIS, a total of 1,365 TCPs have been identified within the study area for the 14 projects. Within the study area the TCPs are located in three different broad locational categories relative to the reservoirs. The TCPs in the study area surrounding each reservoir are either completely inundated, in the fluctuation zone, or above the fluctuation zone. The fluctuation zone is the portion of the reservoir that is regulated between full pool and minimum pool. Table 3-289 shows the distribution of the TCPs relative to each of these zones. For a TCP to be categorized as permanently inundated, at least 75 percent of the boundary must be below the elevation of the reservoir fluctuation zone. Properties that are in the fluctuation zone can be completely within the fluctuation zone; or spanning the fluctuation zone and a portion of the permanently inundated area; or intersecting the fluctuation zone and the area above the fluctuation zone (or a combination).

**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 |

There are seven types of TCPs that will be described in this EIS: hunting areas, fishing sites, gathering areas, habitation locations, legendary sites, cemeteries, and sites that the co-lead agencies lack data to characterize. These types are expanded on below.

Hunting areas are traditional areas that were used for hunting, trapping, tracking, or pursuing animals with the intent to kill them. These are areas that have been used for many generations and frequently have been named. An example of a hunting area that is a TCP is at the mouth of Hellgate Canyon on Lake Roosevelt that has been used traditionally, and is still used, as a hunting location for deer.

Fishing sites are traditional locations where people fish, use fish traps or weirs, or had fishing platforms. These are areas that have been used for many generations and typically have place names. Well known examples for fishing locations include Celilo Falls along the lower Columbia River and Kettle Falls along the upper Columbia River, but fishing sites also include areas that were less well known and may have been used only by a family or a single tribe.

Gathering areas are traditional places where resources are gathered. Some important plants gathered include camas and wapato roots, tule used for basket and mat making, and berries. Other types of resources gathered include stone for making chipped tools, ground tools, and stone pipes and also places where shellfish are gathered. These places have been used for generations and are still used today.

Habitation locations are traditional locations where people have lived. These can be large or small villages or camps used during resource extraction. Frequently these will have cultural remains, such as foundations, house pits, storage pits, resource preparation areas, or refuse areas. For a habitation location to be a TCP it would need to be identified by the living community as a place that was used repeatedly in the past and is still important today for a similar purpose.

Legendary sites are places with historic and cultural value that are referenced in stories. These are usually physical features and landscapes, such as rock outcroppings and formations, buttes, large and distinctive ridges, cliffs, waterfalls, or valleys. An example is a Native American story about Celilo Falls, which is said to be a dam created by the five swallow sisters to block salmon from going up stream. Coyote tricked the sisters and broke the dam resulting in salmon being able to swim upstream. As punishment for keeping salmon from the people, Coyote made swallows fly upstream each year to announce the arrival of salmon (Hunn et al. 2015; NW Council 2019a).

Cemeteries are a place where the remains of the dead are interred. Because cemeteries represent a physical tie between their ancestors and the lands where they live, cemeteries are seen as being important in the preservation of community identity.

“Agency lacking data to characterize” sites are TCPs that do not fit into the above categories. Examples of such TCPs include places where wild horses used to run along Grand Coulee, the mouth of rivers and creeks, trails and roads, locations of rapids in rivers, towns that were inundated with the construction of dams, and locations of landslides. While there may be stories associated with some features, such as the landslide that created the Bridge of the Gods, other similar features do not have a story associated with them and could not be put in the legendary sites category.

#### *3.16.2.7 Sacred Sites*

Executive Order 13007 directs that Federal agencies shall accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners, to the extent practicable, permitted by law, and not clearly inconsistent with essential agency functions. It also states that Federal agencies will avoid adversely affecting the physical integrity of sacred sites, but like the provision regarding access, this is subject to restrictions based on practicability, legality, and essential agency function. Where appropriate, agencies will maintain the confidentiality of sacred sites. As defined in the Executive Order, a sacred site "means any specific, discrete, narrowly delineated location on Federal land that is identified by an Indian tribe, or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious importance to, or ceremonial use by, an Indian religion; provided that the tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of such a site" (Clinton 1996). The Executive Order states agencies with Federal lands are to ensure notification if an action is to affect the physical integrity of sacred sites or if future access or ceremonial use of a sacred site is to be restricted.

Pursuant to the Executive Order, the co-lead agencies for the CRSO EIS contacted 19 tribes to request their assistance in identifying sacred sites within the study area. As a result of this effort Kettle Falls at Grand Coulee and Bear Paw Rock at Albeni Falls were identified as sacred sites. Although only two sacred sites were identified in keeping with the definition in the Executive Order, it is likely that many other sacred sites could be identified as part of consideration of future projects. Many tribal representatives had concerns regarding confidentiality and disclosure of sacred sites. Co-lead agencies received information from one tribal representative identifying all federal lands in the cultural resources study area along the Columbia and much of the lower Snake rivers as a sacred site. The co-lead agencies believe this does not meet the definition in the Executive Order as it is not discrete or narrowly delineated.

### 3.16.3 Environmental Consequences

#### *3.16.3.1 Introduction*

**ARCHAEOLOGICAL RESOURCES**

**Introduction**

Effects on archaeological resources are assessed based on the extent to which an alternative increases the potential for erosion and other processes that contribute to archaeological resource damage and decay. Erosion adversely affects archaeological sites by removing human burials, artifacts, features such as fire hearths and house pits, and other valuable information. Reservoir draft and refill cycles are the primary sources of erosion at storage pools. Rapid raising and lowering of a pool can undermine shoreline stability. For sites in the drawdown zone below full pool, exposure can result in erosion from wind and water runoff (gullying and sheet erosion). Erosion can accelerate in drawdown zones when normally submerged, quickly flowing rivers reemerge, and when wave action works along temporary banks that form during drawdowns. Drawdown zones can also affect site integrity by increasing accessibility and visibility, resulting in site vandalism, looting, and artifact collection. The exposure also increases the chances of inadvertent damage caused by livestock trampling and recreational activities.

This analysis will look at the frequency, amplitude, and rate of reservoir elevation changes as a measure of reservoir operations that enhance erosion. In addition, this analysis will consider the time period that archaeological resources are exposed, given the correlation between exposure and adverse effects. For all erosion metrics, it is assumed that a stable environment results in less erosion and decay of archaeological resources over time and is therefore "beneficial" for archaeological resources, at least in comparison to other alternatives that feature less stability.

**Methodology**

**Exposure**

Given that exposure of inundated archaeological resource is generally an adverse effect, it is helpful to have metrics to describe the extent of exposure and thus be able to compare effects of different alternatives. Two variables need to be considered. First is the time period of exposure, or the number of days that the drawdown zone is going to be exposed. Second is the area of the archaeological resources. Archaeological resources can vary in size greatly, from isolated features covering just a few feet to large village sites that stretch for miles. If an area is exposed that contains no archaeological resources, that exposure has no consequences for archaeological resources. On the other hand, if an exposed area does have archaeological resources, then that exposure does have consequences.

One way to combine these two variables (time and area) for comparison purposes is to multiply the acreage of archaeological resources in a reservoir by the number days that those acres would be exposed – in other words, an "acre-day." A single "acre-day" is the amount of exposure created when an archaeological site covering 1 acre is exposed for 1 day. In the same way, a half-acre site exposed for 2 days would also be 1 acre-day of exposure. Ten acres of archaeological site exposed for 10 days would be 100 acre-days, and so on. For a single artifact, a very small collection of related artifacts, or occasionally a single feature, termed an isolate or isolated find, the states utilize different definitions of isolates and they often represent a single point on the landscape with no calculated area or acreage. Because of this, isolates were not used in the analysis. For the tables that follow, the calculations are based on a single water year.

The data used to support this analysis comes from two sources. First, the information about the amount of time that particular areas would be exposed come from the reservoir operations modeling described in Section 3.2 of this EIS. For example, under typical conditions in the No Action Alternative, Lake Roosevelt is at full pool at 1,290 feet and expected to be below elevation 1,260 feet. (i.e., the surface of the reservoir is at an elevation of 1,260 feet above mean sea level) starting by mid-March (about March 15) and ending by late May (about May

20). In other words, areas above elevation 1,260 feet would be exposed at least 67 days every year under typical conditions. See Section 3.2, *Hydrology and Hydraulics,* for more details.

The second part of this analysis comes from archaeological research in the reservoirs. Archaeologists have completed an inventory of the archaeological resources in the immediate vicinity of the reservoirs and in much of the land exposed in the drawdown zone under typical operating conditions. The boundaries of the archaeological resources have been recorded and converted into polygons using GIS. The four states covered by this EIS utilize different definitions of isolates, and often isolates represent a single artifact with no calculated area or acreage. Therefore, isolates were not included in this analysis. This data, combined with bathymetric information regarding the elevation of the lands under the reservoirs' surfaces, allows one to determine which sites are going to be exposed when a reservoir reaches a particular elevation. It also allows determination of how many acres of archaeological resources are going to be exposed. For this analysis, the bathymetric information was treated as a series of contours. The intervals between each contour line usually formed a ribbon that went around the inside of the reservoir like rings within a bathtub. Each ribbon formed a single elevation interval. At some of the storage reservoirs, these intervals could be as large as 40 feet, as the storage reservoirs operate over a large range of elevations. Run-of-river reservoirs, on the other hand, tend to operate over a range of less than 20 feet. For these reservoirs, the elevation intervals were usually 1 foot.

Analysis using GIS allowed the determination of how many acres of archaeological resources were in each elevation interval at each reservoir. This information regarding acreage within each elevation interval was multiplied by the number of days that each interval would be exposed to compile acre-day measurements for each of the reservoirs.

The effects analysis also considers other factors, especially the timing of proposed drawdowns relative to other uses, especially recreation. This will be a qualitative analysis.

The analysis focused on seven of the 14 reservoirs being covered in this EIS. These reservoirs were included in the analysis because H&H modeling showed that there would be moderate to major changes (greater than 5% above the No Action Alternative) in reservoir elevation between different alternatives over the course of a year. The reservoirs included in the analysis are Albeni Falls, Dworshak, Grand Coulee, Hungry Horse, and Libby (all major storage reservoirs), John Day (a storage project that is operated like a run-of-river project because it has limited storage capacity), and Lower Granite (a run-of-river project). For many of the run-of-river reservoirs, this was not the case—differences between the alternatives were often negligible or non-existent, especially if one focused on the median (typical) conditions. This was especially true of Chief Joseph Reservoir (Rufus Woods Lake), which would not undergo any changes in elevation from the current operations. For the remaining reservoirs on the lower Columbia River (including McNary), there was negligible to minor difference in operations between the No Action Alternative and MO1, MO2, and MO3; it is only when one considers MO4 that operational changes become major in the lower Columbia River Projects. In those projects or alternatives where it appears that there were no change, negligible, or minor changes, analysis was limited. See the discussion in Section 3.2 of the modeling effort for more details on this process, particularly some of the statistical assumptions behind the model.

John Day was included because the modeling showed that there would be minor to major changes in reservoir elevation between different alternatives. Reservoir elevations would be higher at certain times of the year under MO1 than under the No Action Alternative, while they would be lower under MO4. It was important to understand the differences between the alternatives to analyze the effects of this variability. At Lower Granite, the representative run of river reservoir, there was little variability between the No Action Alternative and MO1, MO2, and MO4. Under MO3, though, which includes dam breaching, there is a major change in reservoir elevations, as the lower Snake River would largely return to pre-reservoir conditions. Lower Granite was chosen as a representative of the four lower Snake River run-of-river projects that would be changed because of dam breach because the four dams have similar configurations and operations. Part of the reason to choose Lower Granite was because of the availability of some bathymetric data (see below).

The analysis is only as reliable as the information that is available regarding archaeological resource locations and boundaries. While archaeological inventory is complete for areas along the immediate reservoir margins, the inventory of all inundated areas is not complete, largely because archaeological inventory was not completed before the reservoirs were filled in many cases, and the deeper parts of the reservoirs are exposed only rarely. The GIS data used here is the best available record of archaeological resource locations available. Examination of the area of recorded archaeological resources by elevational interval at each of the analyzed reservoirs shows that a greater area of archaeological sites has been recorded in the upper parts of most reservoir pools. This pattern does not reflect pre–Contact settlement practices—it reflects the availability of areas along reservoirs for examination. That is, areas near the upper edge of fluctuating reservoirs are available for examination more commonly than those near the bottom, meaning that resources have a greater chance of being observed and recorded.

A related concern is the reliability of the GIS data regarding bathymetric contours. A variety of sources of bathymetric data were used, some of which are more than 50 years old (Table 3-290). Only the bathymetric contours from Libby are based on recent side-scan sonar soundings. The rest are based on topographic data that were gathered before the reservoirs were filled or during large-scale drawdowns during major construction projects (i.e., Grand Coulee and Hungry Horse). This means that, in most cases, the available data does not necessarily reflect changes in the distribution of sediments that were deposited after the reservoirs were filled.

**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)<br>Asotin, Washington–Idaho (1971)<br>Clarkston, Washington–Idaho (1971)<br>Colton, Washington (1964; photorevised 1975)<br>Granite Point, Washington (1964; photorevised 1975)<br>Kirby, Washington (1964; photorevised 1975)<br>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) |

The available bathymetric data for John Day, Lower Granite, and Albeni Falls reservoirs were based on relatively large-scale intervals. For example, the bathymetric data from John Day and Lower Granite reservoirs were available in either 5- or 10-foot contour intervals. At Albeni Falls, the great depth of Lake Pend Oreille means that the available bathymetric contour intervals are often 25 feet wide.

The problem comes when the available bathymetric data is compared to the operational ranges of these reservoirs. John Day operates over a range of 11 feet, Lower Granite operates over a range of 5 feet, and Albeni Falls operations over a range of about 12 feet. In an ideal situation, the bathymetric contour data would be available for these reservoirs with narrow operating ranges that had 1-foot contour intervals. Unfortunately, such fine-scale data is not available, so it became necessary to estimate the acreage of archaeological resources within each 1-foot contour interval. This was calculated by determining the acreage of archaeological resources within the shallowest bathymetric interval, and then dividing that acreage by the number of feet within the interval. For example, at Albeni Falls, it was determined that there were about 626 acres of archaeological resources within the 12-foot operating range of the reservoir. Dividing 626 acres by 12 feet resulted in an estimate of acreage of archaeological resources within a single foot of reservoir drawdown zone (52 acres per foot).

Finally, it is also important to note that this analysis of exposure focuses on the median conditions as derived from the 5,000-year Monte Carlo simulation developed through the H&H analysis of this EIS, discussed further in Appendix B, Hydrology and Hydraulics Data Analysis. As seen in the summary elevation hydrographs for each of the alternatives, this data includes the daily variation in reservoir elevations, thus capturing some of the seasonal variability in operations. It does not show the extremes of operations that might happen if there was a multi-year drought because the modeling was not continuous from year to year. For the purposes of comparing the alternatives, the median conditions were determined to be the most representative of typical conditions over the long term. It also meant that the analysis would be simplified by only comparing median conditions, rather than by trying to compare dry year, median year, and wet year conditions between each alternative at each reservoir.

**Erosion**

Increases in bank erosion, and in some cases, mass wasting events, have been observed in conjunction with rapid draft and refill events, and with depth of drafts at some storage reservoirs. The influence of each of these factors over erosion rate is dependent on local topography (slope) and geology (sediment structure). Three measures of draft rate are applied in this assessment: draft frequency, draft amplitude, and frequency of high draft rate events.

***Draft Frequency and Amplitude***

For this assessment, draft frequency is the number of reservoir draft and refill sequences within a specified timeframe. When the reservoir elevation goes above the median elevation of the reservoir for that particular water year, it is considered one filling event. When the reservoir goes below the median elevation of the reservoir for that particular water year, it is considered one drafting event. The total number of refilling and drafting events is the measure of draft frequency used here. Median reservoir elevation was used for these calculations because reservoir elevations tend to be skewed toward higher elevations, making median a more meaningful measure of the central pool elevation tendency than the mean. Any increase in the number of times pool elevation passed the median as compared with the current condition is an “adverse” effect, and a reduction in this number is “beneficial.”

Draft amplitude is the difference between minimum and maximum pool elevations as seen within a single water year. For this assessment, it is assumed (and is consistent with field observations) that an increase in draft frequency or amplitude increases erosion rates.

***Frequency of High Draft Rate Events***

Draft rate is another factor influencing the amount of erosion that occurs at some reservoirs in the Columbia River System. For this assessment, draft rate is measured as the number of feet a reservoir is drawn down in a specified time frame (i.e., reservoir elevation change from one day to the next). Each reservoir differs in how it is operated, and each reservoir has different operational ranges, so it is not possible to say that a draft of 1.5 feet between two days at McNary is going to have the same effect as a draft of 1.5 feet between two days at Grand Coulee. McNary is a run-of-river project that operates over a range of about 5 feet, which means that a change of 1.5 feet between two days is a noticeable change. Grand Coulee, on the other hand, is a storage reservoir with an elevational range of more than 80 feet. A 1.5-foot change is a much smaller percentage of the overall depth. There needs to be a way to place draft rates at each of the reservoirs in its appropriate context.

To calculate what should be considered a High Draft Rate Event at each of the reservoirs for each of the alternatives, the first step was to calculate the mean daily draft (or fill) rate, which then enabled one to determine the standard deviation. A High Draft Rate Event was defined as any daily draft that was more than two standard deviations below the mean. This mean and standard deviation was readjusted for each individual water year resulting from the Monte Carlo simulation for each of the reservoirs and alternatives. Individual daily drafts were compared to this threshold, enabling calculation of a count of high draft rate events within a single water year. The average number of high draft rate events for each alternative were then compared to understand the potential for each to increase erosion rates.

#### *Limitations*

The biggest single limitation of this analysis of the frequency, amplitude, and rate of reservoir elevation changes is that the methodology is not suitable as a proxy measure of erosion at the run-of-river projects. Run-of-river reservoirs are not subject to regular seasonal drafting for water storage. Therefore, water surface elevations do not provide the main measure of potential effects of alternative river operations on archaeological sites. As seen in the description of the various operational implications of the alternatives, some of the run-of-river reservoirs often see a variation of elevation of less than 5 feet over the course of a year. The key erosion metric for run-of-river reservoirs is flow rate, (flow rate in cfs). Erosion may not affect as many site acres as storage reservoirs, but erosion effects are more targeted because the run-of-river projects operate in narrower range, consistently affecting the same area of a site over time. Volume and timing of flows are the key variables in understanding the effects of the operational alternatives. See Section 3.2, *Hydrology and Hydraulics*, for more information about variation in flows between the alternatives.

## TRADITIONAL CULTURAL PROPERTIES

### Introduction

The 14 projects that comprise the analysis area for the CRSO EIS also comprise the 14 projects that have been a part of the FCRPS Cultural Resource Program for the last 20+ years. Over that time, numerous studies have documented oral histories or traditions and sites or properties of cultural importance in and around each of the reservoirs. These studies were responsive to a variety of contract statements of work using different objectives and tasks. This has resulted in properties defined in different ways due in many cases to the perspective of different tribes that conducted the studies or different statements of work.

### Analysis

In conducting this analysis, there are several constraints (e.g., the scale of the analysis and number of tribes engaged in the EIS) in the data and an assumption made in the methodology. The assumption is that each property identified by a tribe considered in the analysis is the same as every other from the standpoint of relative importance. The co-lead agencies were unable to determine if any of the properties are more or less important from a tribal perspective. For the purposes of this document they are all considered the same. Not following this assumption would have entailed extensive consultation with 19 tribes to determine individual tribal perspectives of importance on TCPs across the CRS. This would have undoubtedly resulted in differences between the various tribal perspectives that would not have allowed the co-lead agencies a uniform analysis of effects.

Constraints include the use of only geospatial data for the dataset. This is primarily because of the nature of other documentation, which, while potentially more useful, is too sensitive to be shared in a public document. After discussion amongst the co-lead agencies and cooperating agency tribes, it was decided that because of concerns regarding confidentiality, only geospatial data would be used.

Another constraint is the data are associated with only the 10 tribes that were participating actively in the FCRPS Cultural Resource Program at the time of the Notice of Intent to Prepare the EIS and not the additional 9 tribes consulted during the development of the CRS EIS effort. However, many of the 10 tribes are in much closer physical proximity to the 14 projects relative to the other 9 tribes. Nonetheless, physical proximity does not preclude the potential presence of additional properties associated with the 9 tribes that were not included in this analysis.

An additional constraint is the data used in this analysis was developed over many years by many different individuals and organizations under contracts with different methodologies and goals. This is mainly because these contracts were typically to identify properties and assess effects on a specific site or project rather than on the 14 projects as a whole.

The last constraint is that although the tribes who are cooperating agencies have had a limited opportunity to review the data, it has been agency staff conducting the effects analysis rather than contracting the tribes to do it, or working closely with the tribes on an individual basis.

The assumption and these constraints provided the co-lead agencies a balanced methodology to compare effects across all 14 projects and alternatives. Not allowing for the assumption and constraints would have resulted in inconsistencies within the analysis between the projects and alternatives. As previously described, the co-lead agencies utilized a large dataset of over 1300 TCPs to conduct the analysis. The analysis demonstrates the presence of multitudes of TCPs of different types throughout the 14 projects as well as the past, ongoing, and potential future effects that would occur as a result of the different alternatives.

**ELEMENTS OF THE BUILT ENVIRONMENT**

Built resources are defined as buildings, structures, or objects that have reached an age of 50 years old and are still in use. Once a built resource is no longer in use and begins to deteriorate, it becomes an archaeological site, for the purposes of this EIS. Built resources do not need to be eligible for or listed in the National Register of Historic Places to be considered in this analysis.

Eleven categories of built resources were considered during this analysis. They include Dams/Locks, Bridges, Railroads, Ferry Terminals, Irrigation Systems, Recreational Facilities, Residential, Commercial, Port Components, Military Structures, and Religious Structures. Table 3-288 shows if these resources are present in the study area by project. One assumption that can be made is that most built resources are not found in the actual reservoirs, with the exceptions of dams and locks, ferry terminals, foundations of bridges, wharfs and piers that would be part of port components, portions of irrigation systems, and some recreational facilities, such as boat ramps. The remaining built resources are out of the reservoir environment and would not be affected directly by most actions proposed in this EIS, such as the raising and lowering of water levels in the reservoirs or even the breaching of the lower Snake River dams in MO3.

**SACRED SITES**

Through the communication process described above, the involved tribes identified two sacred sites in keeping with the definition provided in Executive Order 13007: Bear Paw Rock, which is on the shore of Lake Pend Oreille at the Albeni Falls Project; and Kettle Falls, which is inundated by Lake Roosevelt, the reservoir created by Grand Coulee Dam.

A tribal government employee designated to represent their tribe with respect to cultural resource issues from the Kalispel Tribe identified Bear Paw Rock as a sacred site. The tribal representative did not provide a specific, discrete, narrowly delineated boundary for the Bear Paw Rock sacred site. For the purposes of this study, the boundaries of the existing known archaeological site will be used as this is entirely on federally owned land. Multiple petroglyphs are located here and are differentiated from other nearby petroglyph sites in that they are deeply carved into the rock, with others nearby being lightly pecked into the rock surface. This site is part of a larger rock art district that is considered eligible for listing in the National Register of Historic Places. It is a location considered known to the public and a popular recreation place. The petroglyph panels here likely represent thousands of years of both continuous tribal activity and continuity in oral traditions related to the importance of the bear paw motif to tribal belief systems.

Tribal government employees designated to represent their tribes with respect to cultural resource issues from both the Kalispel Tribe of Indians and the Confederated Tribes of the Colville Reservation identified Kettle Falls as a sacred site. Neither representative provided a specific, discrete, narrowly delineated boundary for the Kettle Falls sacred site. For the purposes of this EIS, the boundaries of this sacred site will be taken as the boundaries of the Kettle Falls Archaeological District, which was listed in the National Register of Historic Places in 1974. This district includes 19 archaeological sites that were created by Native Americans and others as they lived at Kettle Falls for more than 10,000 years, and it also includes early historic-period sites representing the activities of early European American missionaries and merchants who interacted with the Native Americans who congregated at Kettle Falls for fishing and other traditional activities. The district encompasses about 2,000 acres, and it is centered on the falls themselves, which are now permanently inundated. Some of the archaeological resources and TCPs near the falls become exposed when the reservoir is drawn down, and major features such as Hayes Island temporarily re-emerge, allowing short-term access. Recent features typical of the exercise of Native American spirituality have been observed on these landforms when they re-emerge, indicating the ongoing importance of the area to the Native American community, which never left the area. Despite these periods of short-term access, the primary Native American religious activities (especially salmon fishing) are no longer possible in this location.

### *3.16.3.2 Archaeological Resources Effects Across Alternatives*

**ARCHAEOLOGICAL RESOURCES**

**Exposure**

Table 3-291 shows the results from calculating the acre-days of exposure for each of the seven reservoirs for each of the alternatives within the course of a single year. As one might expect, the largest reservoir considered here (Grand Coulee), has the greatest amount of acre-days. This also reflects the fact that Grand Coulee, as storage reservoir, is often used to regulate flows throughout the rest of the Columbia River System, which means that it has substantial variability in elevation throughout the year, thus resulting in many days of exposure. Lower Granite is a unique case, especially when one considers MO3, which would result in the exposure of all the previously recorded sites. Even though it is a relatively small reservoir, the breach would result in an increase from about 26,000 acre-days under current conditions to more than 260,000 acre-days within a single year. John Day, Dworshak, and Albeni Falls form a second group, where acre-day values range between about 100,000 and 200,000 acre-days. The final group, which includes Lower Granite, Libby, and Hungry Horse, have acre-day values between about 15,000 and 50,000 units.

**Table 3-291. Effects to Archaeological Resources – Acre-Day Calculations by Reservoir and 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 |

Note: Values have been rounded to the nearest thousand.

For this analysis, the four MOs are compared to the baseline condition in the No Action Alternative. This enables us to divide the acre-days exposure for an alternative at a reservoir by the values from the No Action Alternative, resulting in a percentage. As seen in Table 3-292, exposure values range from a decrease of 3 percent from the No Action Alternative values (MO1 for John Day Reservoir) to an increase of 47 percent over the No Action Alternative value (MO4 for Grand Coulee Reservoir). Variation within ±5 percent of the No Action Alternative will be considered negligible to minor, while values with an increase of 6 to 9 percent will be considered moderate. Exposure values with an increase of 10 percent or greater will be considered major. MO3 at Lower Granite presents a unique case, as dam breach is expected to return the lower Snake River to pre-reservoir conditions and expose all the recorded sites. In this case, there is an increase in exposure of more than 900 percent.

**Table 3-292. Effects to Archaeological Resources – Increases or Decreases in Exposure of 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/] |

Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in exposure (an adverse effect), while a negative value indicates a decrease in exposure (a beneficial effect).
1 Percentage change indicates a ±5% change in the amount of exposure and is considered negligible.
2 Percentage change indicates an increase in amount of exposure between 5% and 10% and is a moderate adverse effect.
3 Percentage change indicates an increase in the amount of exposure greater than 10% is considered a major adverse effect.
4 Percentage change indicates a reduction in the amount of exposure greater than 5% and is considered a beneficial effect.

## Erosion

### *Draft Frequency and Amplitude*

Table 3-293 provides a summary of the changes in reservoir elevation changes (i.e., draft frequency). Because this analysis is based on a 5,000-year dataset generated by the Monte Carlo simulation, it is assumed that any large-scale differences in the frequency of reservoir elevation changes are statistically important due to the large size of the dataset. The greatest number of reservoir elevation changes were seen at Grand Coulee for MO1, while the fewest were seen at Libby for MO1. For both Libby and Albeni Falls, the reservoir elevation either went above the median or below the median a little over two times a year. This can be seen in the “AVE” column in the table, which shows the number of times per year that the reservoir level passed above or below the median elevation. At Hungry Horse, the average was about three times a year, while it was about four times a year at Dworshak. At Grand Coulee, which showed the most frequent changes in reservoir elevations, the frequency was closer to six times a year.

**Table 3-293. Effects to Archaeological Resources – Frequency of Reservoir Elevation Changes 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 |

1/ SUM = the number of times that the reservoir elevation went above or below the median in the 5,000-year dataset.
2/ AVE = the average number of times in a single water year that the reservoir went above or below the median.
3/ STDEV = the standard deviation for the average in the adjacent column.

The changes in the total number of elevation changes relative to the median (i.e., SUM in Table 3-294) can also be compared to the No Action Alternative, resulting in a percentage of increase or decrease (i.e., Sum of Action Alternative/Sum of No Action Alternative) (Table 3-294). Values for the No Action Alternative are shown as 0 percent because this was the baseline for comparison to the other alternatives. The greatest reduction in frequency of elevation change is seen at Hungry Horse Reservoir under MO2, where there is a 4.6 percent reduction in the frequency of reservoir elevation changes. The greatest increase is at Grand Coulee under MO1, where there is a 32.1 percent increase in the frequency of reservoir elevation changes.

**Table 3-294. Effects to Archaeological Resources – Average Frequency of Reservoir Elevation 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/] |

Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the average frequency of reservoir elevation changes, which is an adverse effect. A negative value indicates a decrease in the average frequency of reservoir elevation changes, which is a beneficial effect.
1 Increase is greater than 10% relative to the NAA and is considered moderate adverse.
2 Increase is between 5% and 10% and is considered minor adverse.
3 Increase is between 0% and 5% is considered negligible.
4 No difference between the NAA and the alternative.
5 Decrease between 0% and 5% is considered negligible.
6 Decrease between 5% and 10% and is considered minor beneficial.
7 Decrease is greater than 10% relative to the NAA is considered a moderate beneficial.

One can also compare the alternatives based on changes in the amplitude of reservoir elevation changes, as shown in Table 3-295. As already discussed in the operational overview, the reservoirs considered here operate over different ranges. Albeni Falls normally operates over a range of about 12 feet, while other storage reservoirs have much wider elevation ranges. Grand Coulee operates over a range of about 80 feet, while Dworshak, Hungry Horse, and Libby all operate over a range of about 160 feet.

**Table 3-295. Effects to Archaeological Resources – Amplitude of Reservoir Elevation Changes 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 |

Note: Values have been rounded to the nearest tenth of a foot.

The results of the amplitude analysis follow this same general two-part division between Albeni Falls and the other reservoirs where amplitudes are greater (Table 3-296). Albeni Falls would undergo the least change between the MOs as compared to the No Action Alternative. Effectively, there is no difference between the No Action Alternative and MOs at Albeni Falls. The differences between the MOs and the No Action Alternative at Libby are all within ±5 percent of the mean. At Grand Coulee, all the differences between the alternatives in amplitude are ±5 percent of the mean except for MO4, where the amplitude would see an increase of about 9 percent. At Dworshak, the differences between the MOs and the No Action Alternative are within ±5 percent of the mean except for MO2, where amplitude would increase by about 28 percent. Hungry Horse shows the greatest changes in amplitude of all the reservoirs examined here. All of the MOs would increase amplitude by more than 5 percent.

**Table 3-296. Effects to Archaeological Resources – Changes in Average Amplitude of Reservoir 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/] |

Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the average amplitude of reservoir elevation changes, which is an adverse effect. A negative value indicates a decrease in the average amplitude of reservoir elevation changes, which is a beneficial effect.

1 Increase is greater than 10% relative to the NAA and is considered moderate adverse.

2 Increase is between 5% and 10% and is considered minor adverse.

3 Increase is between 0% and 5% is considered negligible.

4 No difference between the NAA and the alternative.

5 Decrease between 0% and 5% is considered negligible.

6 Decrease between 5% and 10% and is considered minor beneficial.

7 Decrease is greater than 10% relative to the NAA is considered a moderate beneficial.

### *Draft Rate*

Finally, the results show differences between the alternatives in the number of high draft rate events (Table 3-297). The greatest number of high draft rate events is seen at Albeni Falls Reservoir, where the mean number of high draft rate events was about 15 times per year. Grand Coulee, which has a greater elevation range than Albeni Falls but less than the other storage reservoirs, usually had about six high draft rate events per year. The other three reservoirs (Dworshak, Hungry Horse, and Libby) all saw about one or two high draft rate events per year.

Comparison of the MOs to the No Action Alternative in terms of the average number of high draft rate events shows a greater level of variability than in the other metrics (Table 3-298). As with the other metrics, Albeni Falls shows the least amount of difference between the No Action Alternative and the MOs; all the differences are within ±5 percent of the No Action Alternative. At Grand Coulee, all differences are within 10 percent of the No Action Alternative, with MO3 and MO4 both showing distinct increases. At Dworshak, MO1 shows a dramatic increase in the average number of High Draft Rate Events, while MO2 shows a marked decrease. Hungry Horse and Libby also show marked differences between the alternatives. At both reservoirs, MO2 shows a distinct increase in High Draft Rate Events, and MO3 also has an increase at Libby. The other alternatives often show a decrease in the High Draft Rate Events.

**Table 3-297. Effects to Archaeological Resources – Rate of Reservoir Elevation Changes by 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 |

**Table 3-298. Effects to Archaeological Resources – Changes in the Average Frequency of High 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/] |

Note: Values have been rounded to the nearest whole percent. A positive value indicates an increase in the average frequency of high amplitude of reservoir elevation changes, which is an adverse effect. A negative value indicates a decrease in the average frequency of high amplitude of reservoir elevation changes, which is a beneficial effect.

1 Increase is greater than 10% relative to the NAA and is considered moderate adverse.
2 Increase is between 5% and 10% and is considered minor adverse.
3 Increase is between 0% and 5% is considered negligible.
4 No difference between the NAA and the alternative.
5 Decrease between 0% and 5% is considered negligible.
6 Decrease between 5% and 10% and is considered minor beneficial.
7 Decrease is greater than 10% relative to the NAA is considered a moderate beneficial.

### *3.16.3.3 No Action Alternative*

#### ARCHAEOLOGICAL RESOURCES

Even though the No Action Alternative is considered the baseline by which the MOs are evaluated, it is important to note that selection of the No Action Alternative would continue to result in substantial degradation of archaeological resources. This was the conclusion of the System Operation Review (SOR) FEIS. Continuation of 2016 operations would result in ongoing loss of archaeological resource integrity. Ongoing degradation of archaeological resources has been documented in the annual reports produced by the FCRPS Cultural Resource Program.

#### Exposure

See Table 3-291 above for information regarding the number of acre-days that archaeological resources would be exposed if the No Action Alternative was selected. There are only a few cases in which the No Action Alternative would result in more adverse effects to archaeological resources resulting from exposure than one of the MOs. Overall, the No Action Alternative would tend to result in less adverse effects to archaeological resources resulting from exposure than the MOs.

**Erosion**

Table 3-297 shows the number of times that reservoir elevations are expected to refill or draft over the course of the 5,000-year Monte Carlo dataset. The effects resulting from the No Action Alternative are within ±5 percent of the effects from the multiple objective alternatives for both Albeni Falls and Dworshak. In the cases of the No Action Alternative for both Albeni Falls and Dworshak, the frequency of reservoir elevation changes for all the MOs are all within ±5 percent of the No Action Alternative (Table 3-298), suggesting that the No Action Alternative would have effects comparable to these other alternatives. At Grand Coulee, Hungry Horse, and Libby, the No Action Alternative would result in about the same frequency of reservoir elevation changes or, in some cases, substantially less changes in reservoir elevation than in comparison to the MOs.

With regard to changes in amplitude of reservoir elevation changes, the No Action Alternative shows fewer adverse effects than the MOs in most cases. There are a few cases in which the No Action Alternative would result in slightly more effects than one of the MOs, but these are minor. For example, in Table 3-296 the Dworshak row shows that MO1, MO3, and MO4 would all result in decreases in amplitude that are less than 1 percent. Changes in operations of this magnitude are considered negligible to minor.

A different pattern is seen in Table 3-298 regarding changes in the number of high draft rate events per year. For this metric, it appears that some of the MOs could result in slightly less draft-driven erosion than the No Action Alternative, especially at Hungry Horse and Libby.

Overall, the No Action Alternative would tend to result in less adverse effects to archaeological resources resulting from erosion than the other alternatives.

**TRADITIONAL CULTURAL PROPERTIES**

Like archaeological resources, there are major effects to TCPs caused by ongoing operations and maintenance. These effects result from all of the authorized purposes at each respective project. However, the intensity and breadth of the impact varies from project to project. For instance, for some projects where navigation is an authorized purpose, there is a relatively higher frequency of barge traffic subjecting TCPs to a greater amount of effects than reservoirs where there is a lesser frequency of barge traffic.

Effects as they relate to TCPs can be broken into eight broad categories: inundation, erosion, public access, visual intrusion, olfactory intrusion, noise intrusion, development, and changes to the natural environment. These can be grouped into direct, indirect, and cumulative effects. Assessing which effects are occurring at which properties and to what extent is difficult to ascertain given the limitations of the available data, as well as the lack of meaningful dialog with the affected tribal communities to determine effects.

The co-lead agencies assume the ongoing effects of inundation and reservoir fluctuation would have major effects to properties. Other potential operational effects associated with these properties can be harder to determine without direct engagement with the affected community and working through effects on a property-by-property basis. However, as noted on page 3-1361, *Analysis*, this was not possible because it would have resulted in inconsistencies in the TCP effects analysis. Effects that are relatively constant throughout a respective reservoir (barge wakes for instance) would cause effects on any properties located within the fluctuation zone. Other effects, such as looting, have occurred at specific properties and are likely to occur in the future at some, but not all properties.

Table 3-299 summarizes effects that have occurred, are occurring, and would continue to occur as a result of the No Action Alternative. Some of these are direct effects resulting from operations and maintenance of the projects. Others are indirect effects and result from the operation and maintenance of the projects but are not directly caused by the operations and maintenance of the projects. Others are cumulative and would not in themselves constitute a significant impact, but taken together or in concert with indirect effects, could rise to the level of a significant impact on specific properties. The Property Specific column in Table 3-299 refers to effects that cannot be ascribed to specific properties without a good sense of where specific property types are located. The Reservoir Wide column in Table 3-299 refers to effects that can be assumed to be occurring to one extent or another across all properties in a given reservoir.

**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 |

| 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 |

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**Effects of Inundation, Erosion, and Sedimentation**

Although the act of inundation itself is a result of construction, outright inundation of these resources as a part of operating the projects has an ongoing effect on the tribal communities that ascribe importance to the properties. This is a result of the reservoir essentially severing the tribal community's ability to access, view, or otherwise refer to an inundated property, except through memory. Partial inundation also has similar effects in that it modifies the appearance of a property relative to its unaltered state. This can include point of reference and partial obstruction of a property. Ongoing erosion has the physical effect of at least partially destroying a property located in the fluctuation zone or undercutting a property resulting in slumping from sediments becoming unstable above the reservoir elevation. Sedimentation can alter the natural appearance of these properties, alter the ability of communities to access these properties, and modify the existing local environment such that plant and animal life traditionally associated with a property are no longer associated.

**ELEMENTS OF THE BUILT ENVIRONMENT**

As part of the No Action Alternative, there would be several structural modifications constructed at various projects. A few of these modifications will have an effect on the built resources. At Bonneville Dam, the gatewell orifice would have structural modifications. As Bonneville Dam is a built resource being more than 50 years old, any modification would be an effect to a built resource. At both McNary and Ice Harbor Dams, proposed structural measures include replacing the turbines, which is an adverse effect to a built resource as the structures are more than 50 years old. The power plant at Hungry Horse Dam began an extensive modernization effort in fiscal year 2018. This work would bring the facilities to current industry standards. It would include the full overhaul or replacement of governors, exciters, fixed-wheel gates, and turbines; a generator rewind; overhaul of the selective withdrawal system; and recoating the penstocks. In addition, cranes that service the power plant would be refurbished or replaced, and the powerplant would be brought up to modern fire protection standards. The replacement of original components of the project would be an effect to built resources by affecting the historic integrity. All other structural measures to the existing projects would have no effect to built resources.

In addition to structural measures, there are planned operations that may effect built resources. At the John Day Project, there is a proposed operational change that would allow for the rapid evacuation of stored water in emergency and unusual conditions. There is a possibility this change could effect built resources downriver such as deterioration to port or irrigation components.

**SACRED SITES**

Implementation of the No Action Alternative would not result in major changes to the Bear Paw Rock sacred site from the present. Ongoing erosion processes may continue to take place, though the surrounding landform is dominated by bedrock. A potential effect from recreational activity may be the ongoing threat of vandalism. The removal of a minimum of at least one individual image from this site has been documented when comparing early historic photographs to the modern condition of the site. Also, other defacement episodes of some of the images has occurred at this location. Any additional vandalism to the site would continue to result in loss of integrity of the petroglyphs that are the outcome of thousands of years of Native American history. However, because many of these features rest on bedrock, typical Lake Pend Oreille operations would not be likely to result in the loss of the landform through erosional effects. Facilitation of short- or long-term access for Native American religious practitioners would not be problematic due to the exposed and stabilized location of the site. Scheduling conflicts with public day use or camping activities at the site may occur.

Implementation of the No Action Alternative would not result in major changes to the Kettle Falls sacred site from the present. Ongoing erosion processes would continue to take place, resulting in progressive loss of sediments that cover the various landforms. This would continue to result in loss of integrity of the archaeological resources that are the outcome of thousands of years of Native American history. However, because many of these features rest on bedrock, typical Lake Roosevelt operations would not likely to result in the total loss of the underlying landforms. During deeper than average drawdowns of Lake Roosevelt, landforms such as Hayes Island would re-emerge, facilitating short-term access for Native American religious practitioners.

**SUMMARY OF EFFECTS**

Selection of the No Action Alternative would continue to result in major degradation of archaeological resources and TCPs due to the direct effects of inundation, erosion, and sedimentation as well as ongoing indirect effects resulting from continued operations and maintenance activities. Several structural modifications are planned at the projects as part of maintenance and capital improvements, some of which may have an effect on the built resources. Implementation of the No Action Alternative would not result in major changes to the Bear Paw Rock or Kettle Falls sacred sites.

See Section 3.16.3.2 for a summary of effects to archaeological resources across all alternatives.

### *3.16.3.4 Multiple Objective Alternative 1*

**ARCHAEOLOGICAL RESOURCES**

**Exposure**

See Table 3-291 above for information regarding the number of acre-days that archaeological resources would be exposed if MO1 was selected. The effects of MO1 in comparison to the baseline established by the No Action Alternative are presented in Table 3-292. In short, implementation of MO1 is expected result in major effects, by increasing the exposure of archaeological resources at Grand Coulee Dam (Lake Roosevelt) by 10 percent, and at Hungry Horse Reservoir by 17 percent. The other reservoirs show negligible changes in exposure as measured by acre-days. Based on the summary elevation hydrographs showing that reservoir elevations under MO1 do not differ from the No Action Alternative for the run-of-river projects that were not analyzed using this technique (i.e., Bonneville, The Dalles, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, and Chief Joseph), no or negligible effects are expected due to changes in exposure.

**Erosion**

Table 3-293 above shows the frequency of reservoir elevation changes for MO1, and the frequency of these changes is compared to the No Action Alternative in Table 3-294. At the five storage reservoirs, MO1 would result in minor effects by altering the frequency of reservoir elevation changes by less than ±5 percent, except for Grand Coulee, where MO1 would result in a major effect of about a 32 percent increase. In terms of amplitude, Table 3-295 compares MO1 to the No Action Alternative. All the changes would be minor except for Hungry Horse, where the amplitude of elevation changes would increase by about 10 percent and would therefore be moderate to major. Considering the number of high draft rate events for MO1, Dworshak would see a major effect with an increase of greater than 100 percent in comparison to No Action Alternative. At Hungry Horse and Libby, on the other hand, there would be a marked decrease in the number of High Draft Rate Events, suggesting that some of the mechanisms of erosion would be restrained.

**TRADITIONAL CULTURAL PROPERTIES**

Under MO1, TCPs would be subject to effects ranging from no change to major, as shown in Table 3-300. However, based on available data and the effects of the MO1 measures, there does not appear to be a change in effects relative to the No Action Alternative at most projects. This is because, operationally, there is not enough difference between the No Action Alternative and MO1 to identify a greater or lesser relative effect as a result of reservoir fluctuations due to operational measures. The exception is Grand Coulee, which is expected to increase in frequency of elevation changes as shown in the archaeological analysis and would likely lead to a greater rate of erosion of properties and therefore a major effect. Dworshak would experience a major effect with a large increase in the number of high draft events which could moderately affect TCPs. However, this is effect uncertain because the high drafts could lead to increased access and visibility of TCPs, which could be beneficial depending on the views of the affected tribal community. The storage reservoirs would be drafted lower and therefore would potentially increase erosion at TCPs. Table 3-300 shows the overall characterization of effects to TCPs by reservoir. No change means TCPs would be expected to incur the same effects under MO1 as they currently do under the No Action Alternative.

**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 effect1/ | Minor effect |
| Lower Monumental | No change | Minor effect | Moderate effect1/ | Minor effect |
| Little Goose | No change | Minor effect | Moderate effect1/ | Minor effect |
| Lower Granite | No change | Minor effect | Moderate effect1/ | 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 |

Note: NA = not applicable. The co-lead agencies had no geospatial TCP data for Libby.

1/ Moderate effects to TCPs at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite are expected immediately following dam breach, but are expected to shift to beneficial effects in the period after due to increased access to these properties by tribal communities.

### ELEMENTS OF THE BUILT ENVIRONMENT

MO1 has several structural measures proposed. Most of the structural measures would not affect built resources because the structures are not 50 years old or because the action is reversible, which means the resource can be restored to a pre-modification state. Table 3-301 shows the structural measures and the magnitude of effect for built resources. At Bonneville Dam, the proposed measure to modify the upper ladder serpentine flow control ladder would affect the fish ladder in a non-reversible manner. At McNary and Ice Harbor, there is a proposed measure to construct additional powerhouse surface passage routes. New construction at the powerhouses, both of which are more than 50 years old, would only affect built resources if the powerhouse itself needs to be modified in some manner to support the new construction. If the new construction does not modify the powerhouses, there would be no effect to built resources. Upgrading spillway weirs to Adjustable Spillway Weirs (ASWs) at John Day, McNary, and Lower Monumental would affect the resources that are more than 50 years old by modifying historic materials and design. MO1 has no structural measures at Dworshak, Chief Joseph, Grand Coulee, Albeni Falls, Libby, or Hungry Horse.

**Table 3-301. Structural Measures Planned Under Multiple Objective Alternative 1 Having an 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). |

There are multiple operational measures proposed under MO1 that could have an adverse effect to historic resources. There would be elevational changes such as deeper drawdowns, at reservoirs such as Grand Coulee, that could affect built resources, such as ferry terminals, recreational facilities, and irrigation. With water levels being at lower levels in some reservoirs, the resources could be unusable. To make them usable, portions of the resources may need to be modified, which would affect the historic value of the built resources. Additionally, the increase and decrease of water level at Grand Coulee could be more or less rapid. Where more rapid, it could cause landslides and erosion, which could cause minor to moderate effects to built resources. Anticipated effects to infrastructure, specifically transportation, resources are discussed in greater detail in section 3.10. Similar to the No Action Alternative, this change could effect built resources, such as ferry terminals, recreational facilities, and irrigation. With water being at lower levels, these resources could be unusable in their current condition. To make them usable, portions of the resources may need to be modified, which may affect the historic value of the built resources. The earlier drawdown at Grand Coulee seen in the winter months could affect built resources including ferry terminals and recreational facilities. By drawing down deeper, some of these resources may need to be modified for continued operation.

**SACRED SITES**

Under MO1, the frequency of deeper drawdowns is not expected to increase at Albeni Falls. Thus, the anticipated effect to Bear Paw Rock under this alternative would remain the same as discussed above in the No Action Alternative.

Under MO1, the frequency of deeper drawdowns at Kettle Falls is expected to increase, and this means that some of the archaeological resources and TCPs associated with this sacred site would be exposed for a greater period. This exposure is likely to result in an increase in looting of materials from the surface of the site, and this looting is often seen as a degradation of the sacredness of the site. At the same time, the increased period of exposure would provide for a somewhat greater level of access to places such as Hayes Island. This may facilitate an increase in Native American religious use of this landform.

**SUMMARY OF EFFECTS**

Implementation of MO1 is expected to result in major effects, by increasing the exposure of archaeological resources at Grand Coulee Dam (Lake Roosevelt) and at Hungry Horse Reservoir. The other reservoirs show negligible changes in exposure. Grand Coulee would increase in frequency of elevation changes and would likely lead to a greater rate of erosion of TCPs. An increase in the number of high draft events at Dworshak could lead to a moderate effect on TCPs, although these effects could also be beneficial with increased access and visibility. Structural measures at McNary and Ice Harbor may have an effect to built resources, as may modification of spillway weirs at John Day, McNary, and Lower Monumental. Operational measures at reservoirs such as Grand Coulee could affect built resources, either by making these built resources unusable for a greater amount of time or by increasing erosion. The frequency of deeper drawdowns at Kettle Falls would result in some of the archaeological resources and TCPs being exposed for a greater period, leading to increased access and use, but also a potential increase in looting.

### *3.16.3.5 Multiple Objective Alternative 2*

**ARCHAEOLOGICAL RESOURCES**

**Exposure**

See Table 3-291 above for information regarding the number of acre-days that archaeological resources would be exposed if MO2 was selected.

The effects of MO2 in comparison to the baseline established by the No Action Alternative are presented in Table 3-292. MO2 would result in major effects at Dworshak and Grand Coulee, which would undergo a 13 percent increase in the exposure of archaeological resources. MO2 would result in moderate effects at Libby and Hungry Horse, which would see an increase in archaeological resource exposure of 8 percent and 6 percent, respectively. The other reservoirs addressed here (John Day, Lower Granite, and Albeni Falls) would not undergo changes in archaeological resource exposure. Based on the similarity between the summary elevation hydrographs for the No Action Alternative and MO2 for most of the run-of-river projects (Bonneville, The Dalles, McNary, Ice Harbor, Lower Monumental, Little Goose, Lower Granite, and Chief Joseph), no differences in exposure are expected at these projects from MO2 as compared with the No Action Alternative.

**Erosion**

Table 3-293 above shows the frequency of reservoir elevation changes for MO2, and the frequency of these changes is compared to the No Action Alternative in Table 3-294. At the five storage reservoirs, MO2 would have minor effects, altering the frequency of reservoir elevation changes by less than ±5 percent, except for Grand Coulee, where MO2 would result in a major effect and an increase of about 26 percent. Major effects to amplitude would be seen at Hungry Horse and Dworshak, where amplitude would increase by 13 percent and 28 percent respectively. Both Hungry Horse and Libby would see major effects with increases in the number of high draft rate events each year.

**TRADITIONAL CULTURAL PROPERTIES**

Under MO2, TCPs would also be subject to direct effects from all authorized purposes at each project, as shown in Table 3-300. Under MO2, there could be increased effects over time at lower Snake River reservoirs because of the proposed operational measure to operate the LSR projects within the full reservoir operating range year round. This measure would allow for more flexibility in operations, which could lead to more frequent shifts in reservoir elevation and thus increased erosion. Properties in Lower Granite, Little Goose, Lower Monumental, and Ice Harbor reservoirs could be subject to effects as a result of implementing this measure, but this does not seem to be borne out by the hydrographs. Similar effects could occur to TCPs in the John Day reservoir by allowing the project to operate within the full reservoir operating range year-round. However, as noted in the archaeological resources effects above, there does not appear to be a change in the hydrographs reflecting a substantial effect from the John Day full pool operational measure. Similarly, by drafting the storage projects slightly deeper for hydropower, effects could occur where TCPs are present in the drawdown zone (Grand Coulee, Hungry Horse, Dworshak) by allowing for wider and more frequent range of shifts in reservoir elevations.

**ELEMENTS OF THE BUILT ENVIRONMENT**

The structural measures in MO2 that would affect built resources would be very similar to those described in MO1 (Table 3-302). At McNary and Ice Harbor, fish surface passage routes to the powerhouses would be added. This action alone would not affect the powerhouses, which are both older than 50 years old, unless there is a need to modify the existing structures. If the existing structures need to be altered in any way, it would affect the historic characteristics to the powerhouses. The proposed measure to upgrade the existing spillway weirs to adjustable spillway weirs at McNary, Ice Harbor, and Lower Monumental projects would result in effects. As these spillways are part of the original construction of the projects, they are more than 50 years old and any modification would affect their historical character. No other proposed structural measures in MO2 would affect built resources.

**Table 3-302. Structural Measures Planned Under Multiple Objective Alternative 2 and Their 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. |

MO2 proposes a number of operational measures that could have an effect on built resources. The operational measures proposed in MO2 are similar to MO1 in that they would create elevational changes at pools. Anticipated effects to infrastructure, specifically transportation, resources are discussed in greater detail in section 3.10. To allow for greater operational flexibility for hydropower generation, there could also be deeper drawdowns, which could result in built resources, such as ferry terminals, recreational facilities, and irrigation, being impacted or altered to make them usable. Ferry terminals at Grand Coulee are a main source of transportation across the reservoir. If there are deeper drawdowns for extended periods of time, it may result in the need to modify the terminals to make them usable to lower elevations. At the Grand Coulee Project, MO2 proposes to have low reservoir levels for extended periods of time. When the pool is at low winter reservoir levels, ferry terminals and recreational facilities, such as boat ramps, are unusable. If there are extended drawdowns, it may be determined that these resources would need to be altered to be usable, especially the ferry terminals, as they are a main source of transportation across the pool. To provide the space needed, the reservoirs would need to be drafted more deeply from mid-December to March. Similar to other operational measures that would create deeper drawdowns, this measure could have a minor effect on built resources, such as ferry terminals, recreational facilities, irrigation, roads, and bridges.

**SACRED SITES**

Under MO2, the frequency of deeper drawdowns is not expected to increase at Albeni Falls. Thus, the anticipated effect to Bear Paw Rock under this alternative would remain the same as discussed above in the No Action Alternative.

Under MO2, the level of effects to Kettle Falls would be similar to that seen under MO1. The frequency of deeper drawdowns is expected to increase under MO2, but not to the same extent as MO1. This means that some of the archaeological resources and TCPs associated with this sacred site would be exposed for a greater period. This exposure is likely to result in an increase in looting of materials from the surface of the site, and this looting is often seen as a degradation of the sacredness of the site. At the same time, the increased period of exposure would provide for a somewhat greater level of access to places such as Hayes Island. This may facilitate an increase in Native American religious use of this landform.

**SUMMARY OF EFFECTS**

MO2 would result in major effects in exposure at Dworshak and Grand Coulee, and moderate effects at Libby and Hungry Horse. MO2 would result in a major effect at Grand Coulee in terms of the frequency of reservoir elevation changes, along with major effects to amplitude at Hungry Horse and Dworshak. Structural measures at McNary and Ice Harbor may have an effect to built resources, as would modification of spillway weirs at John Day, McNary, and Lower Monumental. Operational measures at reservoirs such as Grand Coulee could affect built resources, either by making these built resources unusable or by increasing erosion. The frequency of deeper drawdowns at Kettle Falls would result in some of the archaeological resources and TCPs being exposed for a greater period, leading to increased access and use, but also a potential increase in looting.

### *3.16.3.6 Multiple Objective Alternative 3*

**ARCHAEOLOGICAL RESOURCES**

**Exposure**

See Table 3-291 above for information regarding the number of acre-days that archaeological resources would be exposed if MO3 was selected.

The effects of MO3 in comparison to the baseline established by the No Action Alternative are presented in Table 3-292. Because MO3 would involve breaching the lower Snake River dams, it would have major effects on archaeological resources in comparison to the other alternatives. Therefore, this discussion of exposure will focus on the other dams and reservoirs first, and then cover Lower Granite, which is being included here as representative of the effects on the lower Snake River.

Four of the seven reservoirs analyzed here (John Day, Dworshak, Grand Coulee, and Albeni Falls) would undergo negligible changes in archaeological resource exposure. Libby would see a moderate (8 percent) increase in the exposure of archaeological resources, while Hungry Horse would see a major (18 percent) increase.

MO3 would result in a major effect in exposure of archaeological resources at Lower Granite. Under the No Action Alternative, the exposure of archaeological resources is about 26,000 acre-days per year. Under MO3, with the reservoir being drawn down to the level of the original river, it is assumed here that all archaeological resources identified during the pre-reservoir archaeological investigations would be exposed, resulting in an increase to 265,000 acre-days of archaeological resource exposure. This represents a major (915 percent) increase. If the four lower Snake River reservoirs are considered as a group, breaching the dams would result in the exposure of a total of 293 archaeological sites with an aggregate area of about 2,125 acres, at minimum. Recent experience at other reservoirs with deep drafts suggests that many more sites are likely to be present (see discussion below). However, analysis in Section 3.3, *River Mechanics* of post-reservoir deposition shows that sediments cover some areas along the lower Snake River up to a depth of about 10 feet. (Figure 3-225;Figure 3-226). It is important to note that not every location within the existing reservoir would be covered with the thickness of sediment shown in Figure 3-226. Some areas would experience erosion as shown by the negative values in Figure 3-225.

As discussed in Section 3.3, *River Mechanics*, the general pattern behind Ice Harbor Dam and Lower Monumental Dam is for post-reservoir sediments to be thickest just upstream from the dams, with accumulations trailing off farther upstream. The pools behind Little Goose and Lower Granite show a pattern of sediment accumulation with greatest deposition in the upper half of the reservoirs. Accumulations along the lower Snake River are greatest in the Lower Granite pool, which is the most upriver of the lower Snake River dams and ends up acting as the settling basin for much of the rest of the system. Accumulations are lowest just downstream of the four dams.

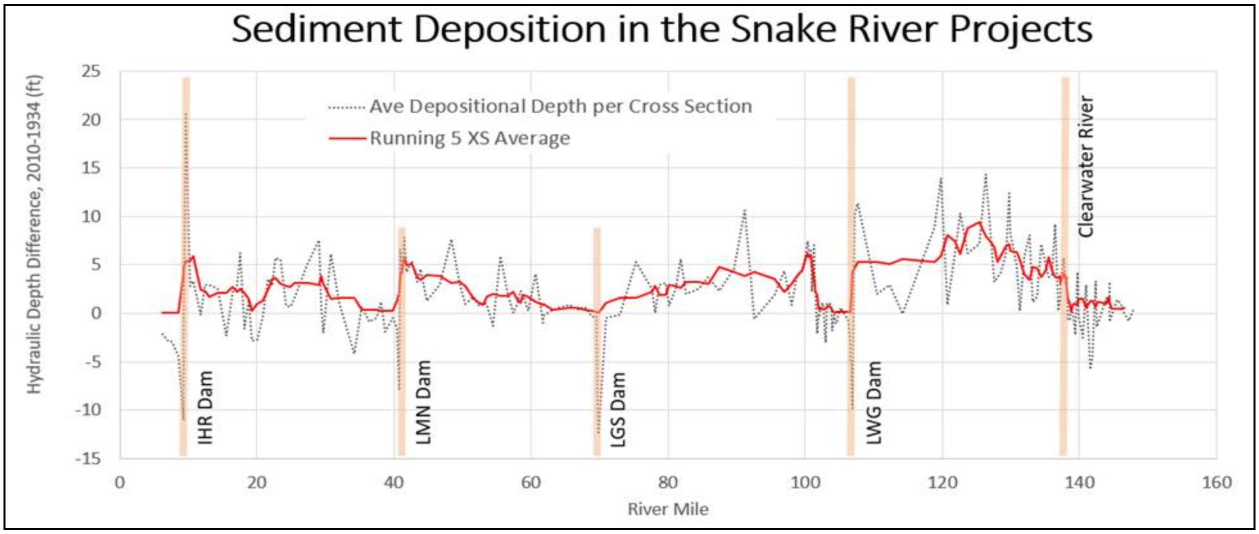


**Figure 3-225. Sediment Deposition in the Snake River Projects**

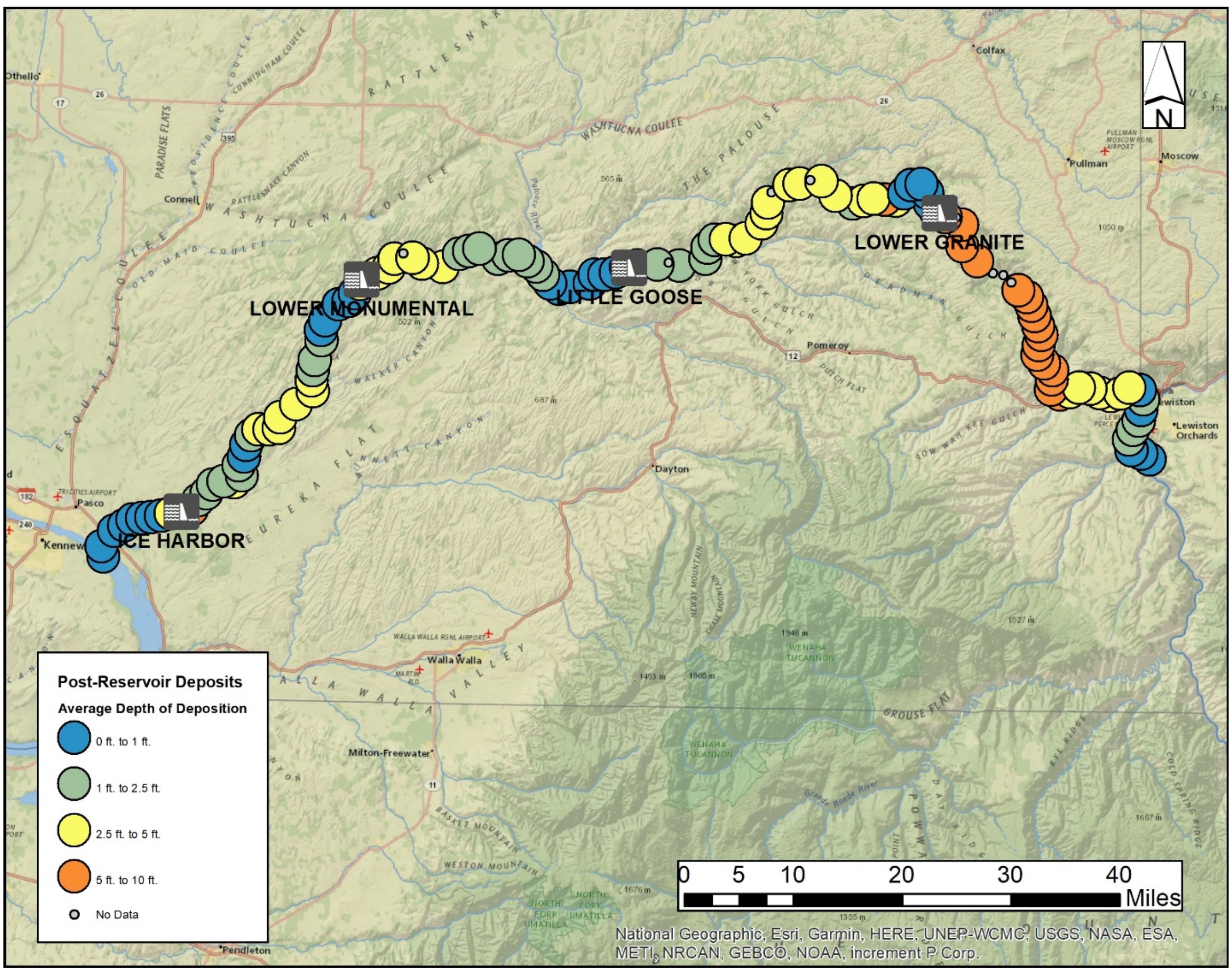


**Figure 3-226. Map of Average Sediment Depth by River Mile in the Snake River Projects**

These patterns of sediment distribution have direct implications for the analysis of MO3 effects to archaeological resources. In some stretches of the lower Snake River, post-reservoir sediments may cap archaeological resources. This is especially true in the stretch of the lower Snake River from the mouth of Alpowa Creek at about River Mile 131 to Lower Granite Dam at about River Mile 107. This "reservoir cap" would have the benefit of obscuring archaeological resources that would otherwise be vulnerable to increased rates of damage by their exposure. The greater thickness of sediments over archaeological sites within Lower Granite Reservoir in comparison to Little Goose was field verified during the 1992 test drawdown (Andrefsky 1992). At the same time, these post-reservoir sediments would not be as consolidated as the pre-reservoir sediments that make up the bed and banks. Researchers working along the lower Snake River during the 1992 test drawdown noted sloughing happening as the river system adjusted to the new conditions (Andrefsky 1992; Dauble and Geist 1992). Slumping, especially of the poorly consolidated post-reservoir sediments, is especially likely given the reduction of reservoir elevation at a rate of 2 feet per day, which is the rate proposed for this alternative.

**Erosion**

Table 3-293 above shows the frequency of reservoir elevation changes for MO3, and the frequency of these changes is compared to the No Action Alternative in Table 3-294. At the five storage reservoirs, MO3 would result in minor effects by altering the frequency of reservoir elevation changes by less than ±5 percent at all the reservoirs. This MO has the least change from the No Action Alternative of all the MOs regarding frequency of reservoir elevation changes. In terms of amplitude of reservoir elevation changes, only Hungry Horse shows a moderate increase in amplitude greater than 5 percent. When it comes to the number of high draft rate events, MO3 shows moderate to major effects with increases greater than 5 percent at Grand Coulee (7.4 percent increase) and Libby (78.4 percent increase) only.

**Other Effects of Multiple Objective Alternative 3**

MO3 is distinctive in the set of alternatives considered here because it includes the breaching of the four lower Snake River dams. Because of this, it is necessary to consider other effects that are unique to this alternative.

One of the consequences of MO3 would be the exposure of approximately 14,000 acres that were formerly inundated (Corps 2002). Over the long term, some of this area is likely to be recolonized by plants, but in other places (especially those lacking nearby perennial sources of water), recolonization would be slow or incomplete. The delay or incompleteness in recolonization would have effects on archaeological resources arising through several mechanisms, which have been observed by site monitors at Lake Roosevelt and other Projects. First, those areas where plant colonization happens slowly or not at all will be prone to gully erosion, especially during late summer thunderstorms when large amounts of rain may be dumped on the ground in a short period of time, or during rain-on-snow events during the late winter and early spring (Figure 3-227). The sheet flow of water across the denuded surface of the drawdown zone could result in dramatic erosion. By removing the soil, artifacts would be shifted in position, making it harder for archaeologists to understand the associations between artifacts and activities.

**Figure 3-227. Gully Erosion in an Exposed Drawdown Zone, Lake Roosevelt, 2017**

Second, the lack of ground cover would also lead to increased indirect effects to sites resulting from human activity, and recent experience with a non-Federal project in another part of Eastern Washington provides a guide on what may occur. In 2014, the reservoir behind Wanapum Dam had to be drawn down to relieve stress during repair of the dam (Lenz 2016). The drawdown resulted in the exposure of areas that had been inundated since the 1960s, and the public responded with great interest. People started driving vehicles on the exposed reservoir bed. Some pedestrians walking on the newly exposed sediments even became stuck in the exposed post-reservoir sediments because they had an almost quicksand like quality. Extraction required the help of law enforcement personnel (Robinson 2014). Because of concerns about both public safety and the integrity of exposed archaeological resources, Grant County Public Utility District #2 worked with property owners to close the reservoir to public access during the entire length of the emergency drawdown (DeLeon 2014).

These lessons can be applied to the breaching of the lower Snake River dams. Archaeological sites located in places where vegetation cover is not quickly reestablished would be much more visible than under typical reservoir operating conditions. The presence of archaeological sites along the lower Snake River is well known to the public (Judd 2017), and exposed sites would be much more likely to be subject to both organized looting and casual collecting of surface artifacts. There is also a high likelihood that vehicles would be driven over the exposed reservoir bed, resulting in degrading of archaeological resource integrity.

Experience from the Wanapum Dam emergency response points to other factors that also need to be considered when managing archaeological resources. Exposed pre- and post-reservoir sediments exposed during the drawdown quickly dried out, resulting in the formation of deep polygonal cracks (Figure 3-228). Because of their size and extent, these cracks allowed recent materials to penetrate deeper into the sediments, resulting in mixing of materials between strata. This kind of mixing degrades the integrity of archaeological resources.

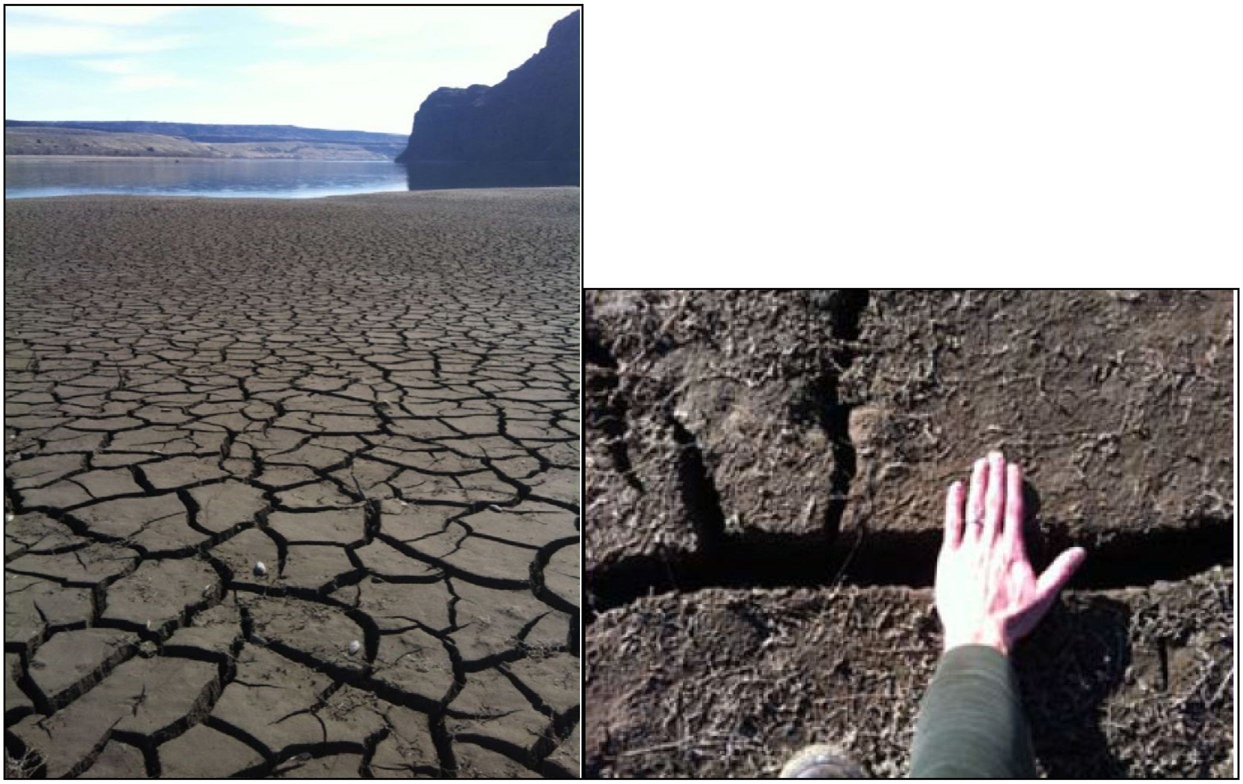

**Figure 3-228. Polygonal Crack Formation, Wanapum Drawdown, 2014**

Source: DeLeon (2014)

Finally, another factor to consider is that we may not fully understand the effects of the drawdown because we do not know the location of all the archaeological resources in the lower Snake River dam pools. During the response to the Wanapum Dam drawdown, the public utility district arranged to have a large archaeological crew conduct an emergency archaeological survey of the exposed area. They relocated 59 previously recorded sites and found 50 new archaeological resources. Lenz (2016) concluded that this recording of a greater number of archaeological resources than were previously known likely resulted from increased thoroughness of archaeological field methods since the 1960s and the much greater ground surface visibility available during a post-reservoir survey when vegetation is not present. Given that the lower Snake River projects were inventoried for archaeological resources at about the same time and using generally the same field methodologies as the contemporaneous Wanapum Pool, it is anticipated that the number of archaeological resources recorded in the lower Snake River pools may increase by about 85 percent after the drawdown. This means that the current count of 293 sites may increase by 249 sites to a total of 542 sites. Overall, MO3 is expected to result in major short-term and long-term effects associated with the breaching of the lower Snake River dams.

Dam breaching could result in increased access to archaeological resources for scientific investigations using conventional terrestrial archaeological techniques. This is a negligible beneficial effect, especially in the context of the adverse major effects resulting from exposure.

**TRADITIONAL CULTURAL PROPERTIES**

Under MO3, TCPs would be subject to effects ranging from no change to moderate as shown in Table 3-269. However, these effects would not be the same at Ice Harbor, Lower Monumental, Little Goose, or Lower Granite projects where moderate effects would occur in the event of dam breaching. Following dam breaching, some properties would experience moderate effects similar to archaeological sites associated with sediment erosion and deposition. Properties could also experience increased indirect effects under MO3 associated with public access including looting, vandalism, creation of trails, and unauthorized activities. These effects could be moderate during the period immediately following the drawdown of each reservoir, particularly in areas in close proximity to access points along the reservoirs or near population centers. During the 1992 test drawdown, some projects experienced an increased public presence simply due to the public having access to areas that had been inundated for more than 20 years.

Following the drawdown, the goal would be for the river to return to as natural a condition as possible. In the long term, this would be expected to have a beneficial effect to TCPs. Many of these properties consist of areas that were used for fishing, gathering, occupation, or legendary sites. Restoration of a natural river would allow tribal communities that attach importance to these areas to access them and, in the long-term, experience the river as it was prior to inundation. Overall, MO3 is expected to result in moderate effects to TCPs affected by the lower Snake River dam breaching.

Moderate effects are also expected to occur at John Day as a result of the John Day full pool operational measure. Overall, MO3 is expected to result in moderate effects to TCPs affected by the lower Snake River dam breaching.

**ELEMENTS OF THE BUILT ENVIRONMENT**

MO3 has several structural measures that would affect built resources (see Table 3-303), but the largest effect to built resources would be the breaching of lower Snake River dams, which involves breaching the earthen embankments, abutments, and adjacent structures of the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite projects would affect the built environment. Lower Granite, built in 1975, has not reached 50 years in age, and as such, the breaching of the dam would not have an effect to built resources at that project. However, Ice Harbor, built in 1961; Lower Monumental, built in 1969; and Little Goose, built in 1970, are all more than 50 years old, and the breaching of the embankment, abutments, and adjacent structures would be a major effect to built resources and would reduce the historic value of the projects. Anticipated effects to infrastructure resources, specifically transportation, are discussed in greater detail in section 3.10.

**Table 3-303. Structural Measures Planned Under Multiple Objective Alternative 3 and Their 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. |

In addition to breaching the dams, there are other structural measures that would amend built resources and reduce the historic value of the projects. Constructing additional powerhouse surface passage routes alone would not affect the powerhouses, which are both greater than 50 years old, unless there is a need to modify the existing structures. If the existing structures need to be altered in any way, it would affect the historic characteristics to the powerhouses. As these spillways are part of the original construction of the projects, they are more than 50 years old and any modification would affect their historical character. Modifying turbines at Ice Harbor, Lower Monumental, Little Goose, and Lower Granite for use as low-level water outlets to support controlled drawdown of the reservoirs would be an effect to built resources because the turbines are original parts of the projects. An alteration to an original component would diminish the historic value of the structures. MO3 has no structural measures at Dworshak, Chief Joseph, Grand Coulee, Albeni Falls, Libby, or Hungry Horse.

Several operational measures that are part of MO3 could create effects to built resources. Modification of equipment for a controlled reservoir evacuation during the dam breach would alter original components of the dams and would ultimately diminish the historic value of Ice Harbor, Lower Monumental, and Little Goose. As with MO1 and MO2, MO3 would have operational changes that create elevational changes in the levels of water at pools. Such changes include lower drawdowns and increases or decreases of water levels that could be more or less rapid. Similar to the other MOs, these changes could result in built resources being affected. Of special concern are ferry terminals and recreational facilities. If any of these resources need to be altered to be usable during lower water levels, it could affect the historic nature of the resources and create a minor effect. Overall, MO3 would have a major effect on the built resources associated with the lower Snake River projects.

As a part of MO3, the agencies would alter the maximum daily draw down rate from 1.5 ft/day to 0.8 ft./day. This change in the drawdown rate means that drawdown has to start earlier in the year than it does currently, resulting in increased periods of exposure at certain elevations. When the pool is at low winter reservoir levels, ferry terminals and recreational facilities, such as boat ramps, are unusable, and MO3 would expand this somewhat. If there are extended drawdowns, it may be determined that these resources would need to be altered to be usable, especially the ferry terminals because they are a main source of transportation across the pool. If this happens, it could change built resources and make them lose historic value. At Hungry Horse, the reservoir could be 4 to 6 feet lower by the end of summer as compared to the No Action Alternative. This may have an effect on built resources, especially recreational facilities. Summer months are the busiest time at the reservoir and when the recreational facilities are used the most. To accommodate a lower reservoir, the facilities may need to be modified to be used, which could change the original components of the built resource.

**SACRED SITES**

Under MO3, the frequency of deeper drawdowns is not expected to increase at Albeni Falls. Thus, the anticipated effect to Bear Paw Rock under this alternative would be the same as discussed above in the No Action Alternative.

MO3 is expected to have similar effects to the Kettle Falls sacred site as described under the No Action Alternative. The changes in operations proposed for Lake Roosevelt under this MO are negligible (at least in terms of elevation), so there should not be a change in effects.

**SUMMARY OF EFFECTS**

Because MO3 would involve breaching the lower Snake River dams, it would have a major effect on archaeological resources in comparison to the other alternatives. In some stretches of the Snake River, post-reservoir sediments may cap archaeological resources and would have major effects. At Lower Granite, archaeological resources would be exposed 915 percent more than under the No Action Alternative. One of the consequences of MO3 would be the exposure of approximately 14,000 acres that were formerly inundated, which would affect archaeological resources through increased erosion, cracking, and increased effects due to human activity.

TCPs initially would be subject to moderate effects under MO3 at the breached lower Snake River projects associated with sediment erosion and deposition, along with increased looting, vandalism, creation of trails, and unauthorized activities. At the same time, the exposure of the TCPs would allow resumption of some traditional uses that have not been possible since the dams were built, and this is viewed as a beneficial effect. Removal of the embankment, abutments, and adjacent structures of the lower Snake River projects would be major effects to these built resources and would reduce their historic value.

### *3.16.3.7 Multiple Objective Alternative 4*

#### ARCHAEOLOGICAL RESOURCES

**Exposure**

See Table 3-291 above for information regarding the number of acre-days that archaeological resources would be exposed if MO4 was selected.

The effects of MO4 in comparison to the baseline established by the No Action Alternative are presented in Table 3-292. Three of the five storage reservoirs show increases in the exposure of archaeological resources in denuded drawdown zones: Albeni Falls, Grand Coulee, and Hungry Horse. Major effects would occur due to increases in exposure at Grand Coulee and Hungry Horse, with exposures increasing by 47 percent and 23 percent respectively. For this alternative, operations would also include lowering the level of John Day Reservoir and the other lower Columbia River projects to help with faster particle travel time for fish migration. This would also have the major effect of increasing exposure of archaeological resources by 23 percent in comparison to the No Action Alternative baseline. Finally, Albeni Falls (Lake Pend Oreille) would undergo a moderate increase of exposure of archaeological resources of about 7 percent. While not as marked as the greatly increased exposures at Grand Coulee, Hungry Horse, and John Day, it is consistent with the overall pattern of substantial increases in pressure on archaeological resources that would be likely to result from implementation of this alternative.

It is important to highlight the effects that would be created by the *Drawdown to MOP* measure, which is an aspect of MO4. The measure would cause the run-of-river projects on the lower Snake and lower Columbia Rivers to be drawn down to MOP during the spring and summer months to reduce fish travel times. The effects of this measure are moderate in that there is a 23 percent increase in acre-day exposure at John Day Reservoir, and it is anticipated that similar effects would take place at the other run-of-river reservoirs, especially along the lower Columbia River. While the *Drawdown to MOP* measure pertains to both the lower Snake and lower Columbia River Projects, the results of the modeling indicate that it would not result in an actual change in operations in the lower Snake River Projects. Summary elevation hydrographs show that the reservoir elevations in the lower Snake River Projects are actually 0.25 foot higher under MO4 than under No Action Alternative during the spring and summer months. However, actual operations would leave these reservoir elevations potentially similar to the NAA. At the lower Columbia River reservoirs, the *Drawdown to MOP* measure results in a lowering of the pool by about 2 to 3 feet, depending on the reservoir. With John Day as a guide, this indicates that the exposure of archaeological sites is likely to experience moderate effects, with an increase in the range of 25 percent in the other run-of-river projects on the lower Columbia River, as well.

**Erosion**

Table 3-293 above shows the frequency of reservoir elevation changes for MO4, and the frequency of these changes is compared to the No Action Alternative in Table 3-294. At all five storage reservoirs, MO4 would result in minor to major effects to archaeological resources through increased frequency of reservoir elevation changes. The situation would be only slightly more adverse at Albeni Falls and Dworshak, but the effects at the other reservoirs would be much more marked. At Grand Coulee, the increase in the frequency of reservoir elevation changes would be about 24 percent.

A somewhat different picture emerges when one looks at the changes in amplitude that would accompany implementation of MO4 (Table 3-295). Again, MO4 would result in moderate effects at both Grand Coulee and Hungry Horse reservoirs due to increases in amplitude. Changes at the other three storage reservoirs would be negligible. Regarding the number of high draft rate events within a single year, again there would be an increase at Grand Coulee, where such events would increase from an average of 5.8 times per year under the No Action Alternative to 6.3 times per year under MO4 (Table 3-296). This represents a moderate effect and an increase of about 8.1 percent. At the other storage reservoirs, the changes in the number of high draft rate events is either negligible (Albeni Falls and Dworshak) or potentially beneficial (Hungry Horse). At Hungry Horse and Libby, implementation of MO4 is likely to reduce the number of high draft rate events within a single year by as much as 59 percent.

MO4 is the alternative that shows the most major adverse effects relative to the No Action Alternative. Although most of the run-of-river reservoirs were not included in the exposure analysis due to a lack of bathymetric data, examination of the summary elevation hydrographs for the lower Columbia River and the lower Snake River projects shows that all of them would undergo lower reservoir levels in comparison with the No Action Alternative during the spring and summer months under MO4. That would also result in increased exposure of archaeological resources during a period when public use of these rivers is increased. This is expected to result in increased damage to the archaeological resources.

**TRADITIONAL CULTURAL PROPERTIES**

Under MO4, TCPs would be subject to effects, as shown in Table 3-300. However, based on the available data and operational measures in MO4, increased effects relative to the No Action Alternative would only occur at the Grand Coulee and Hungry Horse Projects. This is based on the frequency of elevation changes at these reservoirs as described in the archaeological site effect analysis. Other minor effects relative to the No Action Alternative are expected to occur at the run-of-river reservoirs as a result of increased exposure.

## ELEMENTS OF THE BUILT ENVIRONMENT

Several of the structural measures associated with MO4 would be similar to structural measures seen in other alternatives. Table 3-304 shows an evaluation of all the structural measures that are proposed as part of MO4 and their effect to historic resources. Implementation of the proposed measure to construct additional powerhouse surface passage routes alone would not affect the powerhouses, which are both older than 50 years old, unless there is a need to modify the existing structures. If the existing structures need to be altered in any way, it would affect the historic characteristics to the powerhouses. The addition of a spillway weir notch gate insert at the McNary, Ice Harbor, Lower Monumental, and Little Goose projects would modify the original spillways, which would alter the historic value of the projects. No other structural measures in MO4 would affect historic resources. Anticipated effects to infrastructure resources, such as ferry terminals, are discussed in greater detail in section 3.10.

**Table 3-304. Structural Measures Planned Under Multiple Objective Alternative 4 and Their 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. |

There are a few operational measures under MO4 that would affect built resources. When the pool is at low winter reservoir levels, ferry terminals and recreational facilities, such as boat ramps, may be unusable. If there are extended drawdowns, it may be determined that these resources would need to be altered to be usable, especially the ferry terminals, as they are a main source of transportation across the reservoir. These actions may alter the historic resources. Lower summertime reservoir levels at Albeni Falls, along with deeper drafts at Libby and Hungry Horse during the spring could affect built resources, especially recreational facilities, and irrigation features. Spring reservoir levels at Hungry Horse could be up to 15 feet lower than the No Action Alternative if one dry year is followed by another dry year, which could have an effect on built resources, especially recreational facilities.

**SACRED SITES**

Under MO4, effects to Bear Paw Rock would be greater than that seen under the No Action Alternative, MO1, MO2, and MO3. In dryer-than-normal years, the summer reservoir elevation for Albeni Falls Dam would be lower than for the No Action Alternative and other MO Alternatives. Given the bedrock nature of the landform, this MO would not likely have an increased erosional effect. Access to the location may be affected if water levels are lower. This may result in not only less public access, which may be a benefit, but also less tribal visitation to the site.

Under MO4, effects to Kettle Falls would be greater than that seen under MO1 and MO2 to Kettle Falls. The increase in resource exposure is expected to increase markedly under MO4 at Lake Roosevelt. This means that some of the archaeological resources and TCPs associated with this sacred site would be exposed for a greater period. This exposure would be likely to result in an increase in looting of materials from the surface of the site. At the same time, the increased period of exposure would provide for a somewhat greater level of access to places such as Hayes Island. This may facilitate an increase in Native American religious use of this landform.

**SUMMARY OF EFFECTS**

Implementation of MO4 is expected to result in major effects by increasing the exposure of archaeological resources at Grand Coulee Dam (Lake Roosevelt), and Hungry Horse Reservoir. MO4 would have moderate effects on John Day and the other lower Columbia River projects associated with the implementation of the *Drawdown to MOP* measure during spring and summer months to reduce fish travel times measure. MO4 would result in the highest erosion of any of the alternatives as the lower reservoir levels would result in increased exposure of archaeological resources. TCPs would be subject to major effects at Grand Coulee and Hungry Horse. The addition of a spillway weir notch gate insert at the McNary, Ice Harbor, Lower Monumental, and Little Goose projects would modify the original spillways, which would alter the historic value of the projects. Bear Paw Rock and would be subject to greater exposure and effects associated with modification in access. Kettle Falls would be subject to greater exposure and effects associated with erosion and modifications in access.

## 3.17 INDIAN TRUST ASSETS, TRIBAL PERSPECTIVES, AND TRIBAL INTERESTS

The area potentially affected by the CRSO EIS alternatives has served as a homeland since time immemorial for multiple Indian tribes. The rivers and the resources they have historically supported are critical elements of many tribes' sense of place and identity. As a result, any evaluation of CRS operations should consider how changes to river conditions affect tribal interests. This section accordingly considers those effects, which have also been considered throughout this analysis for resources of particular importance to tribes.

The following section discusses the affected environment and environmental consequences for Indian Trust Assets, tribal perspectives, and tribal interests. As discussed below, Indian Trust Assets are a particular type of tribal interest that were analyzed. Certain tribes provided their holistic perspectives on how the CRS affects tribal interests. The co-lead agencies have attached those perspectives in their entirety as appendices, and provided summaries and key excerpts here. Finally, this section evaluates effects to tribal treaty resource interests.

### 3.17.1 Indian Trust Assets

#### *3.17.1.1 Introduction and Background*

The Department of the Interior (DOI) requires that all effects to Indian Trust Assets (ITAs), even those considered nonsignificant, be discussed in NEPA analyses and appropriate compensation and/or mitigation implemented. ITAs are legal interests in property held in trust by the United States for Indian tribes or individuals. ITAs include trust lands, natural resources, trust funds, or other assets held by the Federal government in trust. An Indian trust asset has three components: (1) the trustee, (2) the beneficiary, and (3) the trust asset.

Treaty-reserved rights, for instance, fishing, hunting, and gathering rights on and off reservation, are usufructuary rights that do not meet the Department of Interior (DOI) definition of an ITA. A usufruct is the legal right to use and derive profit or benefit from property that belongs to another person. The United States does not own or otherwise hold these resources in trust. ITAs do not normally include usufructuary rights alone (i.e., rights to access for hunting or fishing). Rather, they require first a possessory interest; that is, the asset must be held or owned by the Federal government as trustee.

Reclamation's NEPA Handbook (2012) recommends a separate ITA section in all NEPA documents including a ROD. These sections should be prepared in consultation with potentially affected tribal trust beneficiaries.

#### *3.17.1.2 Affected Environment*

The area of analysis is defined as the 14 dam and reservoir locations (hydroelectric projects) and an area extending 1 mile in all directions from the reservoir full pool elevation to include the tailrace of each dam.

The co-leads consulted with the following 19 Federally recognized tribes to determine the presence of and effects on ITAs:

- Burns Paiute Tribe
- Coeur d'Alene Tribe of Indians
- Confederated Salish and Kootenai Tribes of the Flathead Reservation
- Confederated Tribes of the Chehalis Reservation
- Confederated Tribes of Grand Ronde Community of Oregon
- Confederated Tribes of Siletz Indians of Oregon
- Confederated Tribes of the Colville Reservation
- Confederated Tribes of the Umatilla Indian Reservation
- Confederated Tribes of Warm Springs Reservation of Oregon
- Confederated Tribes and Bands of the Yakama Nation
- Cowlitz Indian Tribe
- Fort McDermitt Paiute and Shoshone Tribes of the Fort McDermitt Indian Reservation
- Kalispel Tribe of Indians
- Kootenai Tribe of Idaho
- Nez Perce Tribe
- Shoalwater Bay Indian Tribe
- Shoshone-Bannock Tribes of the Fort Hall Reservation
- Shoshone-Paiute Tribes of Duck Valley Reservation
- Spokane Tribe of Indians

Coordination of consultation and information sharing with the tribes was conducted through the Tribal Liaison Team (TLT), which is composed of representatives from all three of the co-lead agencies. A Federal point-of-contact (POC) for each of the 19 tribes was established and serves as the primary conduit for coordination of consultation and information sharing. Conversely, each tribe has identified a POC for similar purposes.

The process for identifying ITAs and evaluating effects from the alternatives includes:

- Initial outreach letter to tribes requesting information.
- Query Reclamation's geospatial database.
- Coordinate with the Bureau of Indian Affairs on identified trust lands.
- Prepare affected environment and environmental consequences sections of the draft EIS.
- Share these sections with tribes who provided input.
- Finalize draft EIS sections.

**GEOSPATIAL DATABASE QUERY**

Reclamation queried its geospatial database that identifies "Native American lands," meaning reservation and trust land, within the study area. Trust land within the study area includes lands from the following tribes:

- Confederated Tribes of Warm Springs Reservation
- Yakama Nation
- Kootenai Tribe of Idaho

The database also includes Indian reservations within the study area. They include:

- Confederated Tribes of the Colville Indian Reservation
- Spokane Tribe of Indians
- Kalispel Tribe of Indians
- Kootenai Tribe of Idaho
- Nez Perce Tribe
- Confederated Salish and Kootenai Tribes of the Flathead Reservation

Reclamation coordinated with the BIA Northwest Regional Office in Portland, Oregon. Those trust lands confirmed by BIA are considered in this ITA analysis.

**TRIBAL OUTREACH**

On July 6, 2018, the co-leads sent a letter to each of the 19 tribes requesting information regarding ITAs. The following section details the information received during the outreach effort and subsequent follow-up with both tribal and Federal POCs. Information was received from the Confederated Tribes of the Colville Reservation, the Nez Perce Tribe, and the Kootenai Tribe of Idaho.

**Confederated Tribes of the Colville Reservation**

A letter was received from the CTCR on September 6, 2018. This letter states that the co-lead agencies "present too narrow a view of the concept [of ITAs]." Further, the CTCR offered their interpretation derived from their reading of the various regulations that discuss ITAs:

> Emphasizing land and water rights ignores other property-based legal interests. The CTRCR's trust assets extend to natural resources such as use of waterways and the fish and wildlife subject to the Tribes' federally protected rights in the Columbia, Okanogan and North Half.

Additionally, the CTCR discussed cultural resources as ITAs:

> Reclamation's guidance is clear. In the Bureau of Reclamation Indian Trust Asset Policy and NEPA Implementing Procedures, on page 3, item 1-6 discusses "When is a Cultural

> Resource an ITA?" The answer is that cultural resources are ITAs, depending on where they are found. Item IV-6, on page 9, describes "How should Reclamation consider effects to cultural resources that may be ITAs?" The answer provided is to follow their responsibilities under NEPA, the Archaeological Resources Protection Act, and the National Historic Preservation Act. Item IV-8, on page 10, asks "Should social and cultural values be considered when addressing impacts on ITAs?" The answer is - "Yes."

The United States does not hold a possessory interest in trust for the benefit of the CTCR or its members for the "use of waterways and the fish and wildlife subject to the Tribes' federally protected rights." The rights of the CTCR to use waterways, hunt, fish, and gather resources are usufructuary rights lacking the trust asset necessary to give rise to an ITA. Nevertheless, given the importance of these resources to the CTCR and other tribes, effects to those resources are discussed in Section 3.17.3, *Tribal Interests*.

For a cultural resource, that is, those resources subject to historic preservation laws, to be considered an ITA often depends on the ownership status of the particular cultural resource and the land on which the resource is found. Cultural resources located on trust land are often the property of the tribe or Indian beneficiary, but could also be held by the United States in trust as part of the real property estate. Cultural resources located on public lands are owned by the Federal government, held for the benefit of the public at large, and are generally not considered ITAs (Bureau Reclamation Indian Trust Asset Policy and NEPA Implementing Procedures, 1994). Cultural resources meeting this definition have been identified. As a result, effects to all cultural resources are discussed in Section 3.16, *Cultural Resources*.

**Nez Perce Tribe**

An email was received from the Nez Perce Tribe on December 4, 2018, and states:

- Indian trust lands (both tribal trust and individual allotment) located within one mile of the main Clearwater River and its three main forks (North, Middle, and South), on the Nez Perce Reservation…
- The Clearwater River bed and banks—that land from ordinary high water mark to ordinary high water mark across the river on the main Clearwater and all three main navigable forks (North, Middle, South)—is tribal trust land and an ITA. (See attached PDF, 2016 DOI M-Opinion (M-37033) confirming trust status). Among other things, Dworshak Dam is located on trust-held riverbed, and trust-held riverbed remains located as well under the portion of the Dworshak Reservoir lying within the 1863 Nez Perce Reservation . . .
- Nez Perce Tribe multi-use/treaty-based water rights within the Nez Perce Reservation are ITAs. (See attached PDF, NPT-SRBA 2007 Consent Decree, listing all of those water rights, from both surface and groundwater sources, within the Reservation.) It is probably acceptable to just consider the smaller subset of those treaty-based water rights for which the water source is the main Clearwater River and its three main forks. Those particular water rights will be found in the initial sections of the attached Consent Decree PDF . . .
- Nez Perce treaty rights reserved in its 1855 Treaty with the United States, and the natural resources subject to those reserved rights, are ITAs, and in this instance include at least Nez

Perce fishing, hunting, and gathering rights, on and off reservation, within the EIS action area; and the fisheries, wildlife, and plant life resources that are subject to those treaty-reserved rights within the EIS action area.

The Department of the Interior does not agree with the Nez Perce Tribe's assertion that treaty hunting, fishing, and gathering rights are ITAs and are subsequently not discussed in this section. However, effects to resources related to treaty rights are discussed in other areas of Chapter 3. Title to the lands encompassing the Clearwater River bed and banks are not identified in the BIA records as trust lands. Those lands are, therefore, not considered as ITAs in this analysis.

Additionally, the Department of Interior recognizes the Nez Perce Tribe's water rights in the Clearwater River. However, effects to those rights are not anticipated since none of the proposed alternatives identify changes in the existing operation of Dworshak Dam.

**Kootenai Tribe of Idaho**

The KTOI requested a map of trust land identified during the geospatial database query. The co-leads responded via email on August 30, 2018, with a map identifying those lands. KTOI responded on September 5, 2018, with a map that includes "all of the lands held in trust by the United States for the benefit of the Kootenai Tribe or individual Indians and some fee land (Mirror Lake) the Tribe intends to place into trust."

The BIA identified those lands currently held in trust for the Kootenai Tribe. Those lands are considered in this analysis; lands not yet held in trust are not considered in this ITA analysis.

#### *3.17.1.3 Environmental Consequences*

No direct or indirect effects to ITAs relative to the no-action alternative were identified for any of the alternatives. Trust lands identified during the geospatial database query and tribal outreach are located outside of any direct or indirect effects identified in the alternatives. These include lands from the Confederated Tribes of Warm Springs Reservation, the Yakama Nation, and the KTOI, as well as the six Indian reservations identified above.

### 3.17.2 Tribal Perspectives Summaries

#### *3.17.2.1 Introduction and Background*

The purpose of this section is to provide federally recognized tribes potentially affected by the operations and maintenance of the Columbia River System (CRS) the opportunity to present, in their own words, their perspective of the operations and maintenance of the CRS, and the effects it has had on tribal life.

As part of the overall CRSO EIS process, the tribes have made clear the importance of presenting with clarity the effects the operations and maintenance of the CRS has had on every facet of tribal culture, both good and bad, since its earliest development. An obstacle to this effort, which was expressed in many forums during consultation between the Federal agencies and the Tribes, was that the Federal agencies failed to understand the holistic connections between natural resources, cultural resources, and the everyday practice of tribal lifeways. This was reflected, they contended, in the agencies' adoption of a definition of "cultural resources" that focused on properties, as suggested by the National Historic Preservation Act, versus a more holistic definition of cultural resources that sees a much broader range of phenomena as cultural resources. For example, several tribes claimed that fish, which are a key part of many Native American ceremonies in the Pacific Northwest, are just as much of a cultural resource as an archaeological site or a historic building. This reliance on a property-based definition of cultural resources is just one example of how the perspective adopted by the agencies is fundamentally at odds with most indigenous peoples' learning systems.

While providing quantitative descriptions of the effects the operations and maintenance of the CRS has had on their communities, the tribes have also provided qualitative accounts of these effects. Qualitative research may be described as "any type of research that produces findings not arrived at by statistical procedures or other means of quantification" (Kovach 2009, 26) which tends to be interpretative, contextual, and narrative in nature. Attempting to capture concepts arrived at through this process, and insert them into a system based on a traditional, positivist quantitative system, based on the empirical investigation of observable phenomena via statistical, mathematical, or computational techniques, has historically been a challenge whenever traditional knowledge-based systems are incorporated into empirical studies. This has also been true for this CRSO process.

This difference in approach was further highlighted when discussing two property types of fundamental importance to the tribes: sacred sites and Indian Trust Assets. Frustrated at the agencies' decision to focus on cultural resources as properties, many of the tribes pointed to their cultural belief system, which calls for a holistic world view and allows for a far broader definition of what they consider as cultural resources. As part of this dialogue, it became apparent that there was a need to address a third type of property-based tribal resource not covered by these headings, and so the tribes were invited to "identify aspects of the affected environment that may not fit under the umbrella of Federal agency regulation resource definitions of sacred sites and Indian trust assets" which could include "but were not limited to, resources of cultural importance, traditional areas, gathering and hunting sites, treaty rights, executive order rights, environmental justice, and other resources." These submittals are included verbatim together as an appendix of the EIS (Appendix P, *Tribal Perspectives*), with this EIS section intended to introduce them and provide a general overview of each one.

Following the dissemination of this invitation and subsequent consultation between the co-lead agencies and tribes, it was decided that, in addition to providing a tribal perspective which would address these resources, the tribes could provide a qualitative statement in keeping with standard EIS investigative models to describe effects to tribal people, and that the relevant portions of this statement would be referenced and included under the appropriate affected environment section of the EIS. Eleven tribal governments responded to the invitation to submit a tribal perspective. These tribes were, the Coeur d'Alene Tribe, the Confederated Tribes of the Colville Reservation, the Confederated Salish and Kootenai Tribes, the

Confederated Tribes of Grand Ronde, the Kootenai Tribe of Idaho, the Spokane Tribe of Indians, the Confederated Bands and Tribes of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Shoshone-Bannock Tribes.

What follows below is a brief discussion of some general themes frequently encountered during consultation with the tribes, followed by a summary of all the tribal perspectives received. Where quotation marks are used, the quote is taken directly from the tribal perspective submittal received.

#### *3.17.2.2 General Overview and Common Themes*

It must be stated from the offset that the purpose of this section is to identify themes that were common to all or most of the tribal perspectives that were submitted and is not an attempt to lump them all together and reduce multiple tribal voices to one. Nor is it an attempt to speak on behalf of the tribes; each tribe has spoken for itself.

**IMPACTS TO TRIBAL CULTURE**

It is difficult to overstate the effects each dam's construction and operation has had to tribal culture, lifeways, and traditions. They have shaken the very foundations of tribal identity and have either undermined or destroyed aspects of tribal culture central to the very concept of being an indigenous person in the Pacific Northwest. These effects have been explicit—the loss of celebrated fishing sites of regional importance such as Celilo and Kettle Falls; and implicit—the loss of the innumerable and unquantifiable intra- and inter-tribal interactions that occurred at these locations; loci-focused ceremonies, traditions, language and customs, dances and song. The loss of these areas has adversely affected how tribal communities define themselves, interact with each other, and live full spiritual lives; and in the process has undermined the processes through which living cultures are nourished, maintained and perpetuated. To put it in terms best understood by non-native people, their loss was not just the loss of a fishing place and traditional foods, but equates to the loss of the marketplace, the town hall, the courthouse, and the cathedral.

Many of the tribes have not only lost access to traditional places, but have lost access to the one thing that all these places had in common, which bound them together and without which they may never even have existed: the salmon. For many of the tribes, any discussion on the operations and maintenance of the CRS that does not include a meaningful discussion on how to return or improve salmon numbers is meaningless.

The loss of these foundational aspects of tribal culture has manifested itself across tribal communities in very tangible ways. The tribes cope with levels of poverty, ill-health, and unemployment at significantly higher proportional rates than any other ethnic group in the country, which in turn leads to significantly higher mortality rates in comparison to non-native communities. These issues are almost entirely the result of the loss of salmon and other traditional foods, the loss of tribal lands, intergenerational trauma, assimilation, and the loss of tribal cohesion.

Just as it is difficult to overstate these effects, it is equally difficult for non-native people to understand the effects tribal communities have suffered with the development of the CRSO. Combined with numerous historical events (encroachment of non-native settlers on aboriginal lands, industrial over-fishing on the Columbia, extensive changes to historical ecosystem-based function, etc.) the cumulative effect has had severe and existential effects on tribal culture and, particularly in the mid-twentieth century, pushed tribal cohesion to the verge of extinction.

**Study Period**

There was some variation among the tribes with regard to the period of study addressed by the EIS. Some argued the baseline against which to measure the effects of the CRSO should be before the dams came into existence; others stated that natural conditions should be considered those that existed at the time treaty rights were negotiated and agreed; while others again insisted that time immemorial should be the measure against which the CRSO is placed. One thing they all agree on is that the date selected, 2016, is arbitrary and limiting the study to that time period omits many key actions the cumulative effects of which continue to be felt.

**Coeur d'Alene Tribe Tribal Perspective Summary**

The following is a summary of the submittal received from the Coeur d'Alene Tribe titled "Affected Environment and Tribal Perspective for the CRSO EIS" sent December 10, 2018 (Appendix P):

Two of the dams in the CRSO, the Chief Joseph and Grand Coulee dams, were "intentionally created without a way for salmon to safely pass over them." This decision "has decimated the salmon runs into our usual and accustomed harvesting locations and the present-day refusal to address this problem results in the continued blockage of descendant salmon."

Salmon are considered a cornerstone of cultural importance to the Coeur d'Alene people (Schitsu'umsh); not just the actual fish and their consumption, but also the customs and practices that existed around the harvesting of them. Their harvest "required a detailed knowledge of nets, weirs and spears constructed of specific materials derived from often unique species of plants and animals. As a result… it was important… to interface with their environment and know where [to] access these important materials."

This activity central to the cultural survival of the Schitsu'umsh necessitated "various tribal events, outings, and ceremonies permeated throughout the year, further strengthening the tribe's sense of place, community and identity." In addition to this intra-tribal activity, these activities resulted in establishing and improving inter-tribal relations because "harvesting occurred in locations shared by other tribes…. [and] brought our friendly, neighboring tribes… to a single location." These gatherings would include various and simultaneous cultural interactions, such as dancing and celebrations, contests, inter-tribal marriages, etc., all of which contributed to and strengthened Schitsu'umsh, tribal identity.

The loss of salmon has served to undermine these activities which once established the Schitsu'umsh sense of tribal identity which in turn has led to the negative consequences of not effectively establishing identity. Statistics for reservations (i.e. poverty, suicide, substance abuse, etc.) can be attributed to the impacts to a people that are struggling with identity. This brings to light the value in providing a qualitative analysis because some things cannot be measured; "In other words, the true impact of the CRSO to the CDA tribe cannot be measured."

Following the submittal of their original tribal perspective section, the Coeur d'Alene Tribe provided an additional section titled "Supplement Information on Tribal Perspective for the CRSO," which was sent April 30, 2019.

This supplement went on to describe the original traditional aboriginal territory of the Schitsu'umsh, and the changes to it resulting from their interaction with the peoples and government of the United States. This interaction resulted in the reduction of their original territory from "more than 5 million acres" in pre-contact times, to a reservation 334,471 acres in size, of which less than one fifth is in tribal ownership.

Schitsu'umsh traditional culture is seasonally based and centered on fishing which took place throughout the year. In their own words, "the history of the dam building era marks a decades long progression during which the Coeur d'Alene Tribe was systematically removed from the anadromous resources that were available to their ancestors" due to the drainages relied upon by the Tribe for anadromous fish harvest being adversely impacted by dam construction and operation: "The loss of these habitats to anadromous fisheries has had a significant and continuing impact on the Coeur d'Alene Tribe's cultural, economic and social well-being."

The effects of this loss have rippled across all aspects of tribal life and have been made manifest in specific symptoms.

- Current fish consumption rates are a tiny fraction of historic levels largely due to the construction and subsequent inundation by the dams. Operational impacts continue to denude critical downstream habitat in areas where salmonid recovery is tenuous. Secondary impacts may include un-quantifiable resource impacts such as: disrupted migration routes of large game and subsequent impacts to herd health and availability.
- The loss of salmon has been identified by the Tribe as an impact of historic trauma, which has included the loss of language, land base and culture, contributing to what psychologist Dr. Eduardo Duran has termed a "soul wound."

  "This wound exists at the community level, where generations of loss require an attention to collective grief that requires collective solutions to heal. The failure of western public health interventions to change the trajectory of health disparities in Indigenous communities 'reflects a non-engagement with the social/cultural drivers of health and the subsequent application of inappropriate intervention models.'"

The supplement provides copious references to studies of American Indian/Alaska Native populations, all of which show disproportional rates of death attributed to quality of life, diet, poverty, and lack of education due to a scarcity of resources. One study cited includes the report titled *Tribal Circumstances & Impacts from the Lower Snake River Project on the Nez Perce, Yakama, Umatilla, Warm Springs, and Shoshone Bannock Tribes* ("Tribal Circumstances Report"), which was prepared by Meyer Resources, Inc., on behalf of the Columbia River Inter-Tribal Fish Commission with funding from the U.S. Army Corps of Engineers for the NEPA process for the Lower Snake River dams. The Tribal Circumstances Report identifies impacts to tribal income/health, life-support resources, and economic base from the status quo operations of the Snake River dams. The supplement indicated that these disproportionate impacts to the economic base, community health and loss of culture are relevant to the Coeur d'Alene Tribe in regard to the impacts of the CRSO.

The studies and information provided by the Coeur d'Alene Tribe identify that a clear link exists between these issues, and the impacts the CRSO has had on tribal culture, society, and life. "The cumulative effects of dam construction have transferred potential wealth produced in the river basin from the salmon on which the tribes depend to electricity production, irrigation of agriculture, water transport services and waste disposal, these latter primarily benefiting non-Indians. These transfers have been a significant contributor to gross poverty, income and health disparities between the tribes and non-Indian neighbors."

**Confederated Tribes of The Colville Reservation Tribal Perspective Summary**

The following is a summary of the submittal received from the CTCR, titled "Tribal Perspectives, Traditional Places, and the Federal Columbia River System" sent March 4, 2019, and presented in full in Appendix P:

CTCR believes that language, songs, ceremonies, rituals, traditional ecological knowledge, religion, legends, cultural expressions, settlement and subsistence patterns, intergenerational knowledge transmission, and other intangible facets of humanity shape the belief, expression and practice of their tribal communities and histories.

These intangible facets are essential to maintaining the continuing cultural identity of the tribes. The impacts of the loss or diminution of these cultural ways are identifiable and can be documented historically, quantitatively, and qualitatively. They are cumulative in origin and result from multiple actions, events, and entities. Hence, attributing any one impact to a particular circumstance, or limiting the chronological examination of multiple impacts to a particular and arbitrary timeframe, undermines the value of the assessment.

The Tribe acknowledges the quantitative challenge in documenting the causal relationship between the loss of those intangible, non-property-based aspects of culture to specific undertakings. Analysis provided by CTCR showed qualitative impacts of how participation in cultural activities have been forced to adapt to physical conditions brought on by changes to the landscape caused by the Federal policies and directives of the CRSO. For example, it was expressed that intergenerational transmission of language, knowledge, and traditional ways are being lost, and that "if ceremonies are not conducted, then language is not spoken as often, legends are not told, family history is forgotten, ritual practices are lost, and the status and role of the elders are diminished."

Nineteen dams and their corresponding reservoirs affect traditional use areas of the CTCR constituent tribes and bands, including the continued total blockage of anadromous salmonids by the construction of Grand Coulee and Chief Joseph dams. This "devastation of the Tribes' ancestral fisheries caused (and continues to cause) irreparable harm to the culture, subsistence, religion, health, social structure, and economy of all twelve constituent tribes and bands." Climate science projections will continue to adversely impact anadromous species, their potential habitats, and CTCR's concerted efforts to reintroduce salmon into the upper Columbia River.

The boundaries of the Colville Reservation were defined with the intent to include fisheries important to the tribes assigned to the Reservation. The completion of the Grand Coulee Dam, and later the Chief Joseph Dam, inundated these fisheries and the regionally important fishery at Kettle Falls and, more significantly, prevented salmon and other anadromous species from reaching much of the Colville Reservation lands, and the lands and waters of the former North Half of the reservation, rendered as public domain in 1891, to which CTCR members retain federally protected reserved hunting, fishing and gathering rights. Consequently, the Tribe's food system and subsistence fishing economy has been destroyed along with the diminishment of "many of the cultural traditions associated with salmon fishing."

In addition to the loss of fish, inundation, transmission, irrigation projects associated with the CRS have significantly and substantially affected the traditional food system, collective health, and subsistence harvesting economy of the CTCR; particularly the unrestricted access to and gathering of traditional cultural plants. Other tribal resources adversely affected by the CRS consist of, but are not limited to:

- Graves and cemeteries
- Springs associated with cultural places and ceremonial activities
- Fishing stations
- Hunting areas
- Plant food, medicine, fiber, and material gathering areas
- Vision quest sites
- Ceremonial locations, e.g., prayer sites, sweathouses, traditional dance locations, vision questing sites and prehistoric sites identified as containing features such as rock rings, cairns, and certain types of talus pits are associated with ritual activity
- Traditional sites
- Named places, i.e., locations that have been given a Native language name
- Legendary locations associated with traditional legends or stories
- Mineral procurement areas

The CTCR ends their supplemental analysis by stating they have no preferred alternative for the CRSO EIS with respect to the protection of cultural resources:

> "Selection of any of the alternatives put forth within Iteration 2 of the Columbia River System Operations EIS will not lessen the continued diminishment and destruction of cultural resources and the traditional food system of the Colville Reservation and other areas in the tribes' traditional territory that are vitally important to the CTCR."

**Confederated Salish and Kootenai Tribes Tribal Perspective Summary**

The following is a summary of the submittal received from the Confederated Salish and Kootenai Tribes (CSKT) titled "CRSO Statement of the CSKT" sent May 9, 2019, and presented in full in Appendix P:

The CSKT assert that "from time immemorial the aboriginal homeland of the Confederated Salish and Kootenai Tribes of the Flathead Reservation reached from what is now British Columbia, down through parts of what are now the states of Idaho, Montana and Wyoming, including the Greater Yellowstone Area." Within this area, no natural resource is more vital to them as a people than water, the importance of which is woven into all aspects of tribal life. Their place on the land and the importance of water to their tribal lives are encapsulated in their recognized Treaty rights and "interests within and to waters and lands that coincide with hydropower facilities and reservoirs of the Federal Columbia River Power System." Specifically, the Kootenai River and the Flathead River systems which include Libby Dam and Hungry Horse Dam, respectively, and their associated reservoirs; Lake Koocanusa and Hungry Horse Reservoir.

Under the Hell Gate Treaty of 1855, the Tribes retained certain rights on ceded aboriginal territory, including, among other things, the right of taking fish at all usual and accustomed places, in common with the citizens of the Territory. Thus, the Tribes assert, and courts have long recognized, that for all Columbia River tributary streams located in the State of Montana the CSKT retain either an exclusive or shared right to manage and use the fishery and other resources. As a result, the Federal action agencies must consider the significant effects, among other things, that "FCRPS operations will have on Tribal waters when proposing Hungry Horse Reservoir drawdowns to support flow augmentation for anadromous fish, because these flows will pass through the Flathead Indian Reservation and accordingly, by timing and volume, affect Tribal water quality."

The Tribe concludes by stating that "Libby Dam, Hungry Horse Dam, and their associated reservoirs inflicted many other serious impacts on the culture, resources, and economy of the CSKT. They caused the inundation of traditional use sites, cultural sites, and archaeological sites."

**Confederated Tribes of Grand Ronde Tribal Perspective Summary**

The following is a summary of the submittal received from the Confederated Tribes of Grand Ronde (CTGR) titled "Blueprint for Characterizing Tribal Cultural Landscapes (TCLs) in the Area of Potential Effect (APE) of the Columbia River System Operations Environmental Impact Statement (CRSO EIS)" which was sent April 26, 2019, and presented in full in Appendix P:

In their submittal the Confederated Tribes of Grand Ronde provided a blueprint for developing the protocols for resource identification and analysis of tribally important resources. Tribally important resources, or Tribal Cultural Landscapes (TCLs), are defined as "any place in which a relationship, past or present, exists between a spatial area, resource, and an associated group of indigenous people whose cultural practices, beliefs, or identity connects them to that place" and can only be defined as significant by tribes and indigenous communities, rather than by exterior criteria. This is a fundamental difference between TCLs and Section 106 TCPs.

This approach recognizes that each "tribe or indigenous group has a unique set of traditional knowledge and lifeways which are inextricably connected to places on the landscape. A group of tribes may all have connections to the same geographic area or overlapping geographic areas, and their connections may differ widely. Therefore, the same geography may carry a vast, wide array of associated tribal resources and knowledge." In keeping with the qualitative tradition, Tribal cultures tend not to separate natural, cultural, historical, ethnographic, archaeological, ecological, spiritual, and subsistence resources from each other in terms of labels or categories. The same location or species may have multiple levels of TCL importance to a single tribe and information specific to a TCL should only come from that tribe.

The CTGR project staff offered this approach "as an alternative means for tribes to identify, gather, and use (and share with others as determined appropriate by the tribe) meaningful information on tribally important places and resources potentially impacted by CRSO-EIS alternatives."

**Kootenai Tribe of Idaho Tribal Perspective Summary**

The following is a summary of the submittal received from the Kootenai Tribe of Idaho and is titled "Kootenai Tribe of Idaho Perspectives on the Columbia River System Operations" and was sent April 26, 2019, and presented in full in Appendix P:

The perspective begins with the statement that "Kootenai Elders and oral Historians say that much of their very early history, including Creation and the beginning of time, is so uniquely Kootenai and so sacred that it cannot be shared with outsiders." They have consented to provide the following information:

- "There is a Creator who made the world.
- You call the Creator God; He told us to call Him Nupika.
- He made different people for different places.
- He made the Kootenai People for this place.
- 'I am your Quilxka Nupika, your supreme being. I have no beginning and no end. I have made my Creation in my image – a circle – and you Kootenai people are within that circle along with everything else in my Creation.

- Remember that everything in my Creation is sacred, and is there for a purpose. Treat it well.
- Take only what you need, and waste nothing.
- Don't commit murder.
- Respect and help one another.
- Cherish your children and your old ones – They are your future and your past.
- Your word must always be good. Never lie, never break a promise.
- At all times, pull together – act with one heart, one mind.
- I have created you Kootenai People to look after this beautiful land, to honor and guard and celebrate my Creation here, in this place. As long as you do that, this land will meet all your needs. Everything necessary for you and your children to live and be happy forever is here, as long as you keep this Covenant with me. Will you do that?'"

The heart of Ktunaxa (Kootenai) Territory is the Kootenai/y River and its tributaries. Libby Dam, which became operational in 1974, is part of the CRSO. The Kootenay River is also impounded by Corra Linn Dam where the west arm of Kootenay Lake flows into the Kootenay River where it meets the Columbia River. Duncan Dam, also authorized by the Columbia River Treaty and spanning the Duncan River, also controls flows into Kootenay Lake. "The construction, inundation and operation of the hydroelectric facilities had a profound impact on Ktunaxa resources and continues to do so. Nearly all the species Ktunaxa relied on for subsistence and cultural purposes are threatened, endangered or extirpated." Consequently, the ability of Ktunaxa people to practice their religion and culture is impeded by the CRSO; however, the CRSO EIS analysis focuses solely on resources in the United States. The Ktunaxa maintain that "it is impossible to fully analyze impacts to Ktunaxa resources with this artificial limitation."

**The Shoshone-Bannock Tribes Tribal Perspective Summary**

The following is a summary of the submittal received from the Shoshone-Bannock Tribes (the Tribes) and is titled "RE: Formal submittal of the Shoshone-Bannock Tribes 'Tribal Perspectives' section for the upcoming CRSO Draft Environmental Impact Statement," sent April 30, 2019. The Shoshone Bannock Tribes recommend the reader review the complete Tribal perspective found in Appendix P, due to the limitations of offering a complete dissertation in the following summary section.

The Tribes believe this document represented "a significant opportunity to promote the conservation of our Tribes' trust resources and the preservation of our salmon culture for future generations" given their "unique view of the issues surrounding anadromous fish management in the context of the operations of the System." The underlying basis of their perspective is the belief that it is time to select an alternative that restores the systems and affected unoccupied lands to a natural condition and as such state "the nearest alternative to this perspective would be for the co-lead agencies to select and implement Multiple Objective - 3 (MO3)."

Their desire to see a return to natural conditions stems from the Tribes' "reliance on the natural riverine ecosystem of the Columbia River Basin for subsistence since time immemorial" which they consider to be enshrined, recognized, and guaranteed, through the Treaty reserved right to hunt on unoccupied lands of the United States. The Tribes hold that their rights and interests are directly impacted by the operation, maintenance, and configuration of the System.

The Tribes explained that, because their approach to addressing issues stemming from the CRSO are stymied by "the boxes of National Environmental Policy Act … and our expanded definitions of Indian Trust Assets and Cultural Resources cannot be heard[,] we feel that the Tribal Perspective section is a welcomed opportunity to express our values, concerns, and risks to the Tribes['] culture and Treaty reserved rights."

The Tribes state that the continued existence of their culture is at risk due to the environmental inequities that have been forced upon them since first contact with non-native settlers in the region. They also state that equitable distribution of environmental risk and benefits has not been afforded to the Tribes, who instead have been "forced to shoulder the burdens of conservation. Because what is at stake now is our Treaty reserved subsistence lifestyle."

In this perspective, the Shoshone and Bannock Peoples' reiterate and refer to what they consider their "Culture of Stewardship" cemented in their relationship with the land since time immemorial, the aim of which is that "Tribal members will have the opportunity to harvest salmon using both traditional and contemporary methods on populations that are sustainable, resilient, and abundant." The Fort Bridger Treaty of 1868 was negotiated and then ratified by Congress in 1869, which reaffirmed the permanent home and reserved off-reservation rights: "they shall have the right to hunt on the unoccupied land of the United States so long as game may be found thereon, and so long as peace subsists among the whites and Indians on the borders of the hunting districts." And that "[p]ersistent today is an instinct to return to the fisheries, resource patches, and lands to continue the heritage of the Shoshone and Bannock peoples."

It is the Tribe's position that the management direction taken by this environmental evaluation will have a significant impact on the Tribes and their cultural resources. Continuation of traditional cultural practices in modern day requires the use of technical innovation combined with essentials of tradition. Tribal identification is found by practicing traditional principles that mirror the images of their ancestors hunting anadromous fish and gathering and giving thanks for the blessings.

In their submittal, the Tribes disagreed with the definition of cultural resources provided under NEPA and Section 106 of the NHPA, and expanded this definition to include "all elements of mind, spirit, and physical being; all are inextricably tied to the physical landscape." This definition includes archaeological sites, historic sites, traditional cultural practices, spiritual beliefs, sacred landscapes, intellectual property, subsistence resources, language and oral tradition, place names, and tribal cultural geography. "The Tribes' definition of cultural resources is based in a holistic perspective that encompasses plants, water, animals and humans, as well as the relationships existing among them." They go on to state that "a cultural resource is any resource of cultural character" and that "A culture existence is dependent on the continuity of interconnected knowledge, beliefs, conventional behavior and technical practices." The traditional cultural practices, including the use of riverine resources, are the foundation on which the Tribes built communities across their homelands for millennia.

While acknowledging the benefits to the region derived from the CRSO, the Tribes assert that these benefits were paid for in kind and disproportionally at the expense of their community's health and well-being while at the same time being expected to "[shoulder] the burden of conservation in our homelands, and losing an important part of our culture along the way."

The Supreme Court of Idaho stated that the "special consideration which is to be accorded the Fort Bridger Treaty fishing right must focus on the historical reason for the treaty fishing right. The gathering of food from open lands and streams constituted both the means of economic subsistence and the foundation of a native culture. Reservation of the right to gather food in this fashion protected the Indians' right to maintain essential elements of their way of life, as a complement to the life defined by the permanent homes, allotted farm lands, compulsory education, technical assistance and pecuniary rewards offered in the treaty. Settlement of the west and the rise of industrial America have significantly circumscribed the opportunities of contemporary Indians to hunt and fish for subsistence and to maintain tribal traditions. But the mere passage of time has not eroded the rights guaranteed by a solemn treaty that both sides pledged on their honor to uphold. As part of its conservation program, the State must extend full recognition to these rights, and the purposes which underlie them." Following on from this the Tribe asserts that "while the Action Agencies utilize a generic definition of Indian Trust Resources, the Tribes view every salmon as a trust asset that should be collectively managed to sustain our Treaty reserved right to harvest those subsistence foods."

The Tribes Policy for Management of the Snake River Basin Resources states: "The Shoshone Bannock Tribes will pursue, promote, and where necessary, initiate efforts to restore the Snake River systems and affected unoccupied lands to a natural condition." Though there were other factors involved, such as commercial over-fishing, populations of salmon decreased substantially with the construction of hydroelectric dams on the Lower Snake and Columbia rivers. The Tribes regard it as their "obligation as managers and stewards of these resources from time immemorial… on the best manner to operate the System and ultimately, recover anadromous fish species to sustainable and harvestable levels" and as such they seek the "restoration of component resources to conditions that most closely represent the ecological characteristics and processes associated with a natural riverine ecosystem."

Continuing the Tribes' view of their culture of stewardship, they view their work to restore the ecosystem to its natural condition as an essential element in the fight against, and to counteract, the effects of climate change, whose "impacts have the potential to affect the entire Basin and resources the Tribes stewarded from time immemorial." Climate change presents a threat to critical cultural resources, thereby also threatening the lifeways and wellbeing of the Tribes. The Tribes view the CRSO, particularly through impacts from slack-water reservoirs and a loss of riverine ecosystem structure and function, as contributors to climate change.

All these factors, combined with changes to the energy market in the Pacific Northwest, culminates in the Tribes presenting an argument in favor of breaching the dams on the Lower Snake River, a move they believe will be of net gain to the region. "The Tribes recognize the benefits that hydropower facilities have had in developing industries and providing electricity to customers in rural areas. However, these benefits were accrued at the expense of fisheries across the Basin, with impacts to Tribal communities who had relied on their presence for millennia" and that "An objective evaluation of these economic conditions would speak strongly in favor of divesting the Snake River component of the System and allow free-flowing river conditions to drive recovery processes for wild anadromous fish stocks in our homelands."

Consequently "The Tribes endorse the selection and implementation of Multiple Objective Alternative 3, which includes the removal of earthen embankments and adjacent structures within the lower four Snake River dams."

**The Nez Perce Tribe, the Confederated Tribes and Bands of the Yakama Nation, The Confederated Tribes of the Warm Springs Reservation, and the Confederated Tribes of the Umatilla Indian Reservation Tribal Perspective Summary**

The Nez Perce Tribe (NPT), the Confederated Tribes and Bands of the Yakama Nation (YN), the Confederated Tribes of the Warm Springs Reservation (CTWSR), and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR), collectively to be referred to as the Lower River Treaty Tribes (LRTTs), with the help of their Columbia River Inter-Tribal Fish Commission, submitted a joint Tribal Perspective which took the 1999 "Tribal Circumstances and Impacts of the Lower Snake River Project on the Nez Perce, Yakama, Umatilla, Warm Springs and Shoshone Bannock Tribes" (the Meyers report) as a foundation to outline tribal concerns and perspectives of the project's effects on "tribal resources, interests, and culture," sent June 11, 2019, and presented in full in Appendix P.

It should be noted that three of the four tribes participated as cooperating agencies, with the caveat that the tribes do not endorse the DEIS by virtue of their participation as cooperating agencies and still intend to provide public comments once the document is released.

The LRTTs Tribal Perspective Submittal provides a substantial overview and thorough background of their treaty-reserved rights to take fish at "usual and accustomed places," which have been confirmed and upheld in key Federal and Supreme Court rulings.

Furthermore, the LRTTs reaffirm that at the time of treaty signing, the tribes understood that through the treaties, the United States was securing the tribes' food. The CRSO doesn't just impact tribal interests, it impacts tribal interests that are secured by treaties with the United States. This concept (along with the proposition that the baseline for measuring effects in the CRSO analysis should be the time of treaty signing) is the heart of the LRTTs document; "...My strength is from the fish; my blood is from the fish, from the roots and the berries. The fish and the game are the essence of my life." The Report also described the importance of salmon to the cultural well-being of tribal people and their sense of belonging to their culture and being part of traditions that define themselves as Indian people as well as their self-esteem as members of their tribes and fulfilling their cultural obligations. The Meyer Report also used tribal poverty, tribal unemployment, tribal per capita income, tribal health and tribal assets as more traditional indicators of tribal well-being which have been severely impacted by dam construction and exacerbated by operations.

The LRTTs state that the "Columbia and lower Snake river dams transformed the production functions of the federally impounded portions of the Columbia and Snake rivers - taking substantial treaty-protected wealth in salmon away from the tribes. At the same time, the dams increased the wealth of non-Indians through enhanced production of electricity, agricultural products, transportation services, flood control, and other associated benefits. As thoroughly documented in the Meyer Report, tribal peoples have not shared in this increased wealth on a commensurate basis. Moreover, the tribes did not share commensurately in the fisheries mitigation that did occur."

Through reference to several previously produced documents, the LRTTs point out the lengths to which they have gone to facilitate the restoration of salmon numbers and by including these initiatives the LRTT seek to demonstrate that the tribes' perspective is to prioritize salmon restoration (the 2014 "Wy-Kan-Ush-Mi Wa-Kish-Wit"; the Columbia River Treaty Tribes' Spirit of the Salmon Plan; "CRITFC, White Sturgeon Hatchery Master Plan: Lower Columbia and Snake River Impoundments, Step 1 Revised" December 15, 2015; the YN annual Status and Trends Annual Report (STAR); the 2013, NPT "Fisheries Management Plan, 2013-2028"; and the 2008 CTUIR River Vision). Similarly, they emphasize the importance of this as evidenced by the work of non-tribal entities that complement the tribal "visions" (Columbia Basin Partnership Task Force, A Vision for Salmon and Steelhead: Goals to Restore Thriving Salmon and Steelhead to the Columbia River Basin [Phase 1 Report to the NOAA Fisheries Marine Fisheries Advisory Committee], Final Draft Report [March 28, 2019]; The 2014 Columbia River Basin Fish and Wildlife Program; the Accords Agreement).

The LRTTs Tribal Perspective document highlights two topics that underpinned the 1999 Meyer Report: the abundance of focal fish species and effects of the Federal hydro system on anadromous fish survival. Adult salmon, sturgeon and lamprey abundance, and tribal harvest, are still far removed from historical levels. The LRTTs Tribal Perspective document provides in-depth discussion of salmon abundance, smolt to adult survival rates, reach survival, CRSO DEIS alternatives, and juvenile salmon reach survival. The LRTTs request that the TP be read in full, presented in Appendix P.

The LRTTs insist "The DEIS must respect the Columbia River Treaty Tribes' culture, food, and ways of life" and that "Fish and wildlife conservation, compliance with environmental laws and addressing Tribes' treaty rights go hand in hand."

The LRTTs make clear that they feel the analysis of the EIS is limited as it does not adequately address other fish stocks such as Columbia yearling Chinook salmon and steelhead.

**Spokane Tribe of Indians Tribal Perspective Summary**

The following is a summary of the submittal received from the Spokane Tribe of Indians and is titled "Columbia River System Operation: Tribal Perspective," sent June 11, 2019, and presented in full in Appendix P:

This submittal states clearly the connection the Spokane Tribe of Indians has had with the inland waterways of the Pacific Northwest, specifically the Spokane River, since time immemorial "The Spokane Tribe of Indians traces a deep and rich history that is tied to inland northwest waterways, especially the Spokane River. …. Often called 'People of the River,' the Spokane people have considered the river that bears their name a sacred place that provided food and a place to call home."

This long association with the waterways, and inhabitation of their associated hinterlands, has resulted in the establishment of strong cultural and societal links between the Spokane Tribe of Indians and these rivers "The locale contains dozens of significant and irreplaceable ancestral cultural sites, both sacred and profane. The importance of these sites lies not only in the artifacts themselves, but in the history contained within the objects (singly and collectively), features, pictographs, and landscapes. Moreover, hundreds, if not thousands of Spokane ancestors were laid to rest along this waterway and many of them remain here." As a result of this close association and symbiotic relationship with these waterways, "the Spokane Tribe considers the entire Spokane Arm a traditional cultural place."

### *3.17.2.3 Agency Consideration of Tribal Perspectives*

The tribes' perspectives provide a wealth of information regarding historical and current effects of the CRS to resources, rights, and interests of the tribes. Combining these perspectives with the resource specific analyses from this chapter provides agency leadership important information to consider in the evaluation of a preferred alternative. The following description of the four MOs and the No Action Alternative summarizes the agencies' interpretation and consideration of the tribal input on these alternatives. In Chapter 7, the agencies considered Tribal Perspectives in formulating the Preferred Alternative.

**NO ACTION ALTERNATIVE (NAA)**

The no action alternative includes the many operational and structural modifications to the CRS that have occurred over the past several decades. The major focus of these improvements has been related to improving fish passage and survival, but identification, mitigation, and protection of cultural resources has been a focus. While many tribes generally acknowledge there have been improvements relative to earlier configurations and operations, most tribes have been clear that not enough is being done to adequately protect or mitigate impacts to tribal interests.

**MO1**

This alternative focuses on several actions intended to benefit anadromous and resident fish while also including measures for water management flexibility, hydropower production, and additional water supply. There are benefits to tribal interests under this alternative, but there are also some localized adverse effects to resident fish in upper basin areas which could be perceived negatively by tribes in those regions. Like many of the alternatives, MO1 attempts to balance many interests and improve conditions for fish while maintaining flexibility for the congressionally authorized purposes. Tribal perspectives, which convey the numerous effects of the system upon tribes over many decades, suggest this alternative may be viewed as not doing enough to address tribal interests.

**MO2**

A primary goal of this alternative was to increase hydropower production and reduce regional greenhouse gas emissions. There are minor to major adverse effects to tribal interests under this alternative. Both resident and anadromous fish are adversely affected, as are cultural resources. While this alternative includes several structural measures targeted at improving fish passage, the operational changes are generally not favorable to tribal interests. Among the range of alternatives evaluated, this alternative is likely to be the least supported by tribes based on its potential effects to tribal interests.

**MO3**

This alternative was specifically identified by several tribes as preferable relative to the range of alternatives analyzed in this EIS. Most tribes support breaching the four lower Snake River dams. This action most closely resembles the historic, pre-dam condition that supported tribes since time immemorial. Even with uncertainty regarding the magnitude of effects of dam breaching to resources, such as anadromous fish, many tribes would likely support this alternative as it represents the only alternative that substantially attempts to restore the river to a more natural environment. Additionally, some tribes could interpret dam breaching as a meaningful milestone in salmon restoration efforts. The co-lead agencies recognize the support for this alternative by a number of tribes.

**MO4**

This alternative includes the highest spill levels, many structural changes to improve fish passage, and storage reservoir drawdowns in the upper basin to augment flows for fish in the lower basin. At the lower Snake and lower Columbia River projects, reservoirs are lowered to potentially improve fish migration. While this alternative provides a number of expected benefits to anadromous fish, it could adversely affect other tribal interests including resident fish (particularly in upper basin areas) and cultural resources. The level of support among tribes for this alternative likely varies by primary geographic area of interest; upper basin tribes may be less supportive than lower basin tribes.

### 3.17.3 Tribal Interests

Tribes in the Columbia River Basin have treaty rights, federally reserved rights, and other interests in the study area and in many of the resources described in Chapter 3. The existing tribal and reservation structure is largely the result of treaties between the U.S. government and the tribes during the period of Euro-American settlement of the West. Isaac Stevens, Washington Territorial Governor, negotiated a series of major treaties with Columbia River Basin (and Puget Sound) Tribes in 1855 (see Table 3-305). Other treaties followed in the 1860s.

**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<br>(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 |

1/ Negotiated at the Walla Walla Treaty Council.
2/ Source: SOR; 2-28 Ruby and Brown, 1992.

These treaties generally were the means by which the tribes ceded tens of millions of acres of land to the United States in exchange for the creation of reservations and the preservation of certain rights. The most discussed (and litigated) right is the right to fish, but the treaties contain other rights as well, including hunting, gathering, pasturing, and travel rights.

A treaty is a contract between sovereign nations. Article VI of the U.S. Constitution recognizes treaties, along with federal statutes and the constitution of the United States, as the "supreme Law of the Land." Treaties can be abrogated (nullified) by Congress, but must be enforced as long as they remain valid. The treaties bind the Federal government as a whole. The CRSO co-lead agencies consequently have an affirmative legal duty to comply with the treaties.

The Federal government discontinued formal treaty making with tribes in 1871. Since then, the government has formally and legally recognized tribes primarily by Executive Order, subject to approval by both houses of Congress. Though Executive Order tribes cannot share in off-reservation reserved rights except by specific agreement, their legal status is the same as for treaty tribes.

Treaty rights and how they have been recognized and practiced has been tested in court since their adoption. Despite the rights retained by the treaties, there is a long and ongoing history of litigation to turn that legal formality into on-the-ground reality. This litigation includes a number of Supreme Court cases over more than a century.

The treaties bind all parties and are the supreme law of the land. The co-lead agencies recognize and respect that supremacy. As a result, the co-lead agencies will comply with the treaties, just as they will comply with all other federal laws.

Where it is applicable or pertinent, under certain resources, the co-lead agencies have attempted to describe how tribal interests would be impacted by the different action alternatives in various sections of Chapters 3 and 7.

The Cultural Resources, Sacred Sites, and Indian Trust Assets analyses include information and analysis pertinent to tribes within the study area. By their nature, those sections have robust discussions of tribal interests and do not have a separate tribal interests section at the end.

## 3.18 ENVIRONMENTAL JUSTICE

### 3.18.1 Introduction and Background

Executive Order (E.O.) 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, was issued in 1994.[1] According to the Council on Environmental Quality (CEQ) guidance for implementing E.O. 12898 under NEPA, "[a]gencies should consider the composition of the affected area, to determine whether minority populations, low-income populations, or Indian tribes are present in the area affected by the proposed action, and if so whether there may be disproportionately high and adverse human health or environmental effects on minority populations, low-income populations, or Indian tribes" (CEQ 1997). The CEQ regulations define "human health or environmental effects" to include economic, environmental, social, cultural, or health-related impacts whether direct, indirect or cumulative (40 C.F.R. § 1508.8 and CEQ 1997).

EPA defines environmental justice as, "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA 2018).[2] Environmental justice analyses identify and address, when appropriate, disproportionately high and adverse effects of Federal agency actions on minority populations, low-income populations, and Indian tribes. In Chapter 1, Section 1.5 describes the NEPA process and steps taken to involve the public and coordinate with tribal governments.

Guidance from CEQ for analysis of environmental justice impacts recommends consideration of the degree to which unique exposure pathways, including subsistence fishing, hunting, or gathering in minority or low-income populations, may amplify the identified effects of an action (CEQ 1997). As appropriate, the environmental justice analysis in this EIS will describe unique conditions of the identified minority populations, low-income populations, and Indian tribes that may heighten their vulnerability to impacts from the alternatives. Based on guidance (NEPA Committee and Federal Interagency Working Group on Environmental Justice 2016, 15), these unique conditions may include these specific vulnerabilities: (1) human health (e.g., heightened disease susceptibility, health disparities); (2) socioeconomic (e.g., reliance on a particular resource that may be affected by the proposed action, disruptions to community mobility and access as a result of infrastructure development); and (3) cultural (e.g., traditional cultural properties [TCPs] and ceremonies, fish consumption practices). Section 3.16, *Cultural Resources*, of this EIS describes three property-based categories, including archaeological sites, TCPs, and historic built resources. Section 3.17, *Indian Trust Assets, Tribal Perspectives and Tribal Interests* captures other resources of tribal interest that do not fit within Section 3.16.

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[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.

#### *3.18.1.1 Area of Analysis*

The study area for the environmental justice analysis is intended to include areas where minority populations, low-income populations, or Indian tribes may be affected by CRSO alternatives.

The populations considered in the environmental justice analysis are located in areas that may be affected by changes to resources potentially impacted including hydropower operations, rates, or both;[3] changes to municipal, industrial, or agricultural water deliveries; changes in the availability or quality of recreation sites; physical impacts to cultural resources; changes in fish and wildlife populations; or changes in use of the CRSO areas for navigation and transportation. The study area for power effects is larger than the study areas for other resources, as the potential impact from changes in power rates is broader. Counties in which these effects may occur were identified, resulting in an environmental justice study area comprising 139 counties across these states: Washington, Oregon, Idaho, Montana, Wyoming, Nevada, and California. The specific granularity of the environmental justice analysis by resource area is dependent on the level of detail included in the associated resource-specific analyses in this EIS.

### 3.18.2 Affected Environment

Consistent with E.O. 12898, this section identifies low-income and minority populations within the study area based on the most recent socioeconomic statistics currently available from the Census American Community Survey (ACS) 5-year estimates from 2012 to 2016. In this analysis, census block groups meet environmental justice criteria if more than 20 percent of the population is below the poverty level or if the percentage of the population that identifies as minority in the census block group is greater than the percentage of the state which identifies as minority. Poverty level refers to poverty thresholds, or the dollar amount the Census uses to determine the poverty status of a person or a family. These thresholds are updated each year by the Census.[4] Indian tribes within the study area are also identified.

This section evaluates low-income and minority populations at the census block group level. In total, there are 8,793 census block groups in the 139-county study area. Census block groups were selected as the geographic scale of analysis because these block groups provide comprehensive coverage of the entire study area at the finest level of data available from the Census for the analysis. A census block group is the smallest geographic area for which the Census provides consistent sample data. Census block groups contain between 600 and 3,000 people or 240 to 1,200 housing units as statistical divisions of census tracts, which contain

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[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.

between 1,200 and 8,000 people. A census block group consists of a contiguous cluster of blocks within the same census tract (Census 2018a).[5]

Counties within the study area were evaluated by census block group to determine where low-income and minority populations are present. Data from the 2012–2016 Census ACS was used to identify census block groups that meet criteria for a low-income population, a minority population, or both. In addition to low-income populations and minority populations, Indian tribes were also identified for consideration in the environmental justice analysis based on GIS information from the Census indicating the location of Indian Reservation and other off-reservation trust lands included in the study area.[6]

Demographic information for counties and Indian tribes in the environmental justice study area has been collected from the U.S. Census and is presented in Appendix O, *Environmental Justice*. This data include metrics typically used by researchers and in EPA's Environmental Justice Mapping and Screening Tool (EJSCREEN) to represent the "social vulnerability" characteristics of a disadvantaged population (EPA 2017).

#### *3.18.2.1 Identification of Low-Income Populations*

Low-income populations are identified based on the percentage of residents in a census block group living below the poverty level, where the poverty level refers to the dollar amount the Census uses to determine the poverty status of a family or a person. The 2016 poverty level (i.e. poverty threshold) for the United States ranges from $12,228 for an individual to $24,563 for a household of four (Census 2018b). The Census defines a "poverty area" as a census tract or block numbering area with 20 percent or more of its residents below the poverty level (Census 2016). For this analysis, census block groups for which the Census reports that 20 percent or more of the population is living below the poverty level are categorized as low-income populations. Data from the ACS indicating the ratio of income to poverty level for individuals in a given area were used for this comparison. Areas with an income to poverty level ratio of less than one fall below the poverty level. Using these data, if the percentage of individuals with income below the poverty level is greater than 20 percent, the area is considered low income. Figure 3-229 illustrates census block groups within the study area which are considered low-income populations for purposes of this analysis. In total, approximately one quarter of census block groups across the study area (2,226 out of 8,793 total) had more than 20 percent of their population living below the poverty level in 2016. These low-income census block groups had a combined population of approximately 3.2 million, which represents approximately one quarter of the total population of 13.2 million in the study area. A more detailed breakdown of low-income populations by county is provided in Appendix O, *Environmental Justice*.

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[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.

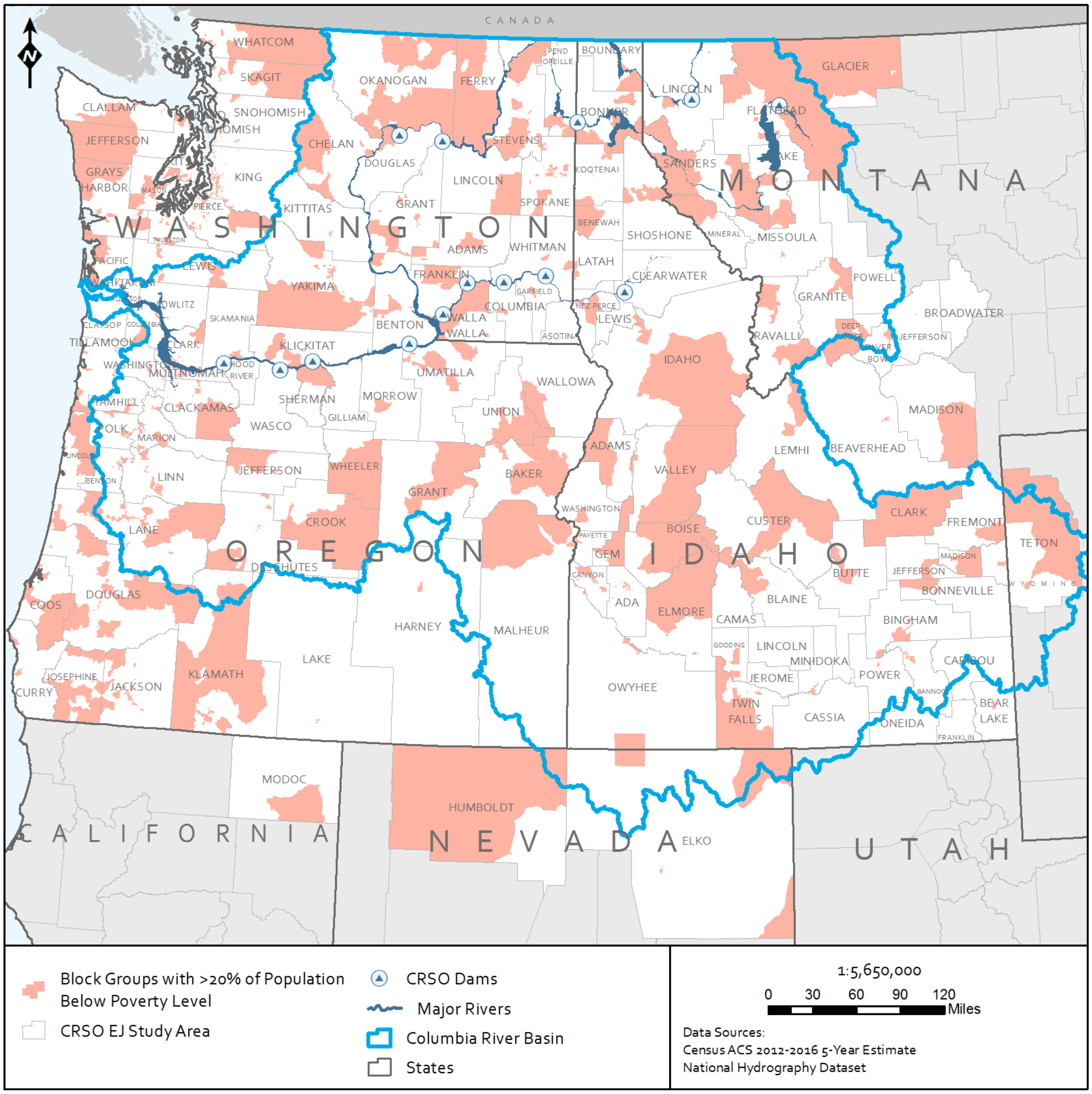


**Figure 3-229. Low-Income Populations in the Study Area**

*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.

### *3.18.2.2 Identification of Minority Populations*

This analysis applies the CEQ guidance (CEQ 1997) to identify minority populations.[7] For purposes of the environmental justice analysis, minority populations are identified by comparing the minority population percentage in an affected area (i.e., census block group) to the minority population percentage in the associated state population (i.e., general population). Areas with a higher percentage of minority population than the statewide minority population percentage are classified as minority populations. For purposes of the analysis, "minority" includes individuals who list their racial status as a race other than White Alone and/or list their ethnicity as Hispanic or Latino. The statewide minority population percentage used for comparison is shown in Table 3-306, which also provides a breakdown of racial and ethnic 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).

**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% |

1/ A breakdown of race and ethnicity at the county level for counties within the study area can be found in Environmental Justice Appendix.

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 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). 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 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 in the Hispanic or Latino category.

3/ For purposes of this analysis, minority population reflects all populations not identified as "Not Hispanic or Latino: White alone" in the ACS.

Source: U.S. Census Bureau (2017b)

The majority of residents in each state identify as White Alone, ranging from 51 to 87 percent of statewide populations, with the exception of California in which only 38 percent of residents identify as White Alone (not Hispanic or Latino). The Hispanic or Latino population represents the second highest racial/ethnic group behind White Alone in all states except Montana in which the second largest racial/ethnic group is American Indian or Alaskan Native Alone.

Figure 3-230 illustrates census block groups within the 139-county study area that are identified as minority populations based on the 2012–2016 ACS (Census 2017a). In the study area, 3,174 of 8,793 total census block groups (36 percent) have a minority population percentage in the census block group that is greater than the statewide minority population percentage. These "minority" census block groups had a combined population of over 5.2 million, comprising 39 percent of the study area population. A more detailed breakdown of minority populations by county is provided in Appendix O, *Environmental Justice*.

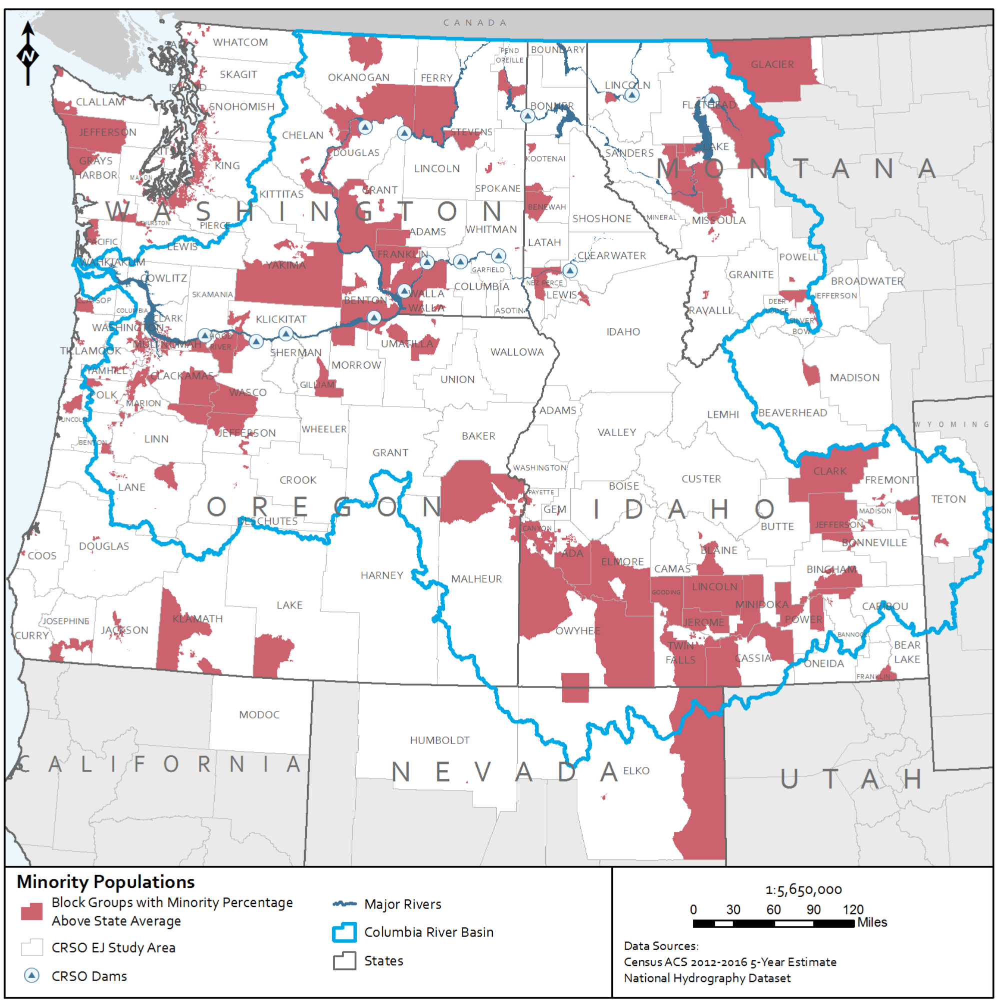


**Figure 3-230. Minority Populations in the Study Area**

*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.

#### *3.18.2.3 Identification of Indian Tribes*

Indian tribes in the Columbia River Basin rely on the Columbia River, its tributaries, and surrounding areas, for fishing, hunting, gathering, and conducting traditional and religious ceremonies. Tribal cultural and social values typically reflect a higher intensity and range of use of natural resources by tribal communities than the general population. Natural and cultural resources associated with the Columbia River Basin are of critical importance to Indian tribes in the region for subsistence, commerce, preservation of cultural traditions and history, religious practice, and self-determination as sovereign nations. Salmon and Pacific lamprey are, in particular, part of the spiritual and cultural identity of most of the Columbia River Basin's Indian tribes. These fish are among the traditional foods that are honored in many tribal ceremonies. A summary of the historical uses of the Columbia River Basin by Native Americans, as well as some of the factors that have led to current conditions, are discussed in Section 3.16 *Cultural Resources* and Section 3.17 *Indian Trust Assets, Tribal Perspectives and Tribal Interests* of this EIS. As discussed, the current areas that are identified as reservation lands or off-reservation lands held in trust for the Indian tribes are a small portion of the areas historically used by the Indian tribes. Figure 3-231 identifies current Indian reservation and off-reservation trust lands within the environmental justice study area.

Demographic information for Indian tribes in the study area has been collected from the Census and is presented in Appendix O, *Environmental Justice*. These data include metrics typically used by researchers and in EPA's EJSCREEN to represent the "social vulnerability" characteristics of a disadvantaged population (EPA 2017). Census information presented in Appendix O demonstrates that, in most cases, the populations residing on reservation lands (as well as off-reservation trust lands) in the study area have higher poverty rates, higher unemployment, and lower household and per capita incomes than the averages for the states where they are located.

The current lack of prosperity on Indian reservations is due to numerous factors. Miller (2012) provides context for the situation on Indian reservations throughout the United States, stressing both the current lack of vibrant functioning economies on Indian reservations, as well as the importance of developing functioning economies in Indian communities to create economic stability which, in turn, enables community building and preservation of culture. A 2012 report found that among tribal populations on and near Washington's tribal reservations, each employed person supported more than three others who were not employed, versus a ratio of one to one in Washington generally (Taylor 2012). The labor participation rate was 39 percent among tribal populations on or near reservations in Washington compared with 74 percent across Washington State in general (Taylor 2012). Another report highlights the circumstances of the Indian tribes located in the lower Snake River region (Nez Perce, Yakama, Umatilla, Warm Springs, and Shoshone-Bannock Tribes), but is broadly applicable in the Columbia River Basin:

> Viewed from the perspective of objective statistics, the peoples of the study tribes must today cope with overwhelming levels of poverty, unemployment that is between three and thirteen times higher than for the region's non-Indians, and rates of death that are from twenty percent higher to more than twice the death rate for residents of Washington, Oregon and Idaho as a whole (Meyer Resources 1999).

The report goes on to describe principal causes of the present impoverishment of the study tribes include the loss of salmon and the loss of tribal lands (Meyer Resources 1999).

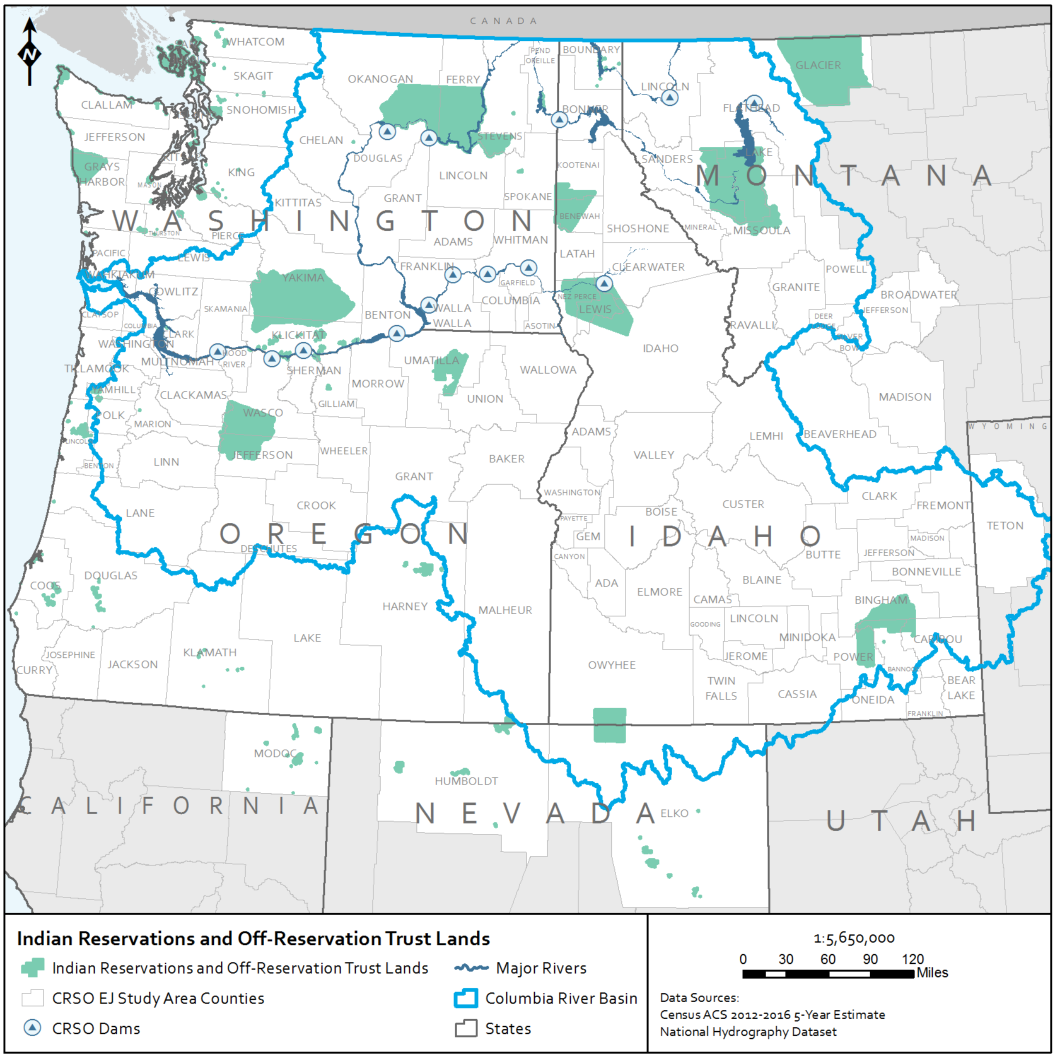


**Figure 3-231. Indian Reservations and Off-Reservation Trust Lands within CRSO Regions**

*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.

Note: Per Census, "[t]he boundaries for federally recognized American Indian reservations and off-reservation trust lands are as of January 1, 2017, as reported by the federally recognized tribal governments through the Census Bureau's Boundary and Annexation Survey" (Census 2017b). The Census layer is incomplete, missing some off-reservation trust lands, in-lieu fishing sites, and fishing access sites.

Source: Census (2017b)

### *3.18.2.4 Summary of Populations Considered in the Environmental Justice Analysis*

Figure 3-232 provides a geographic representation of the locations of minority populations, low-income populations, and Indian tribes within the study area. This includes 4,169 (out of a total of 8,793) census block groups identified as minority, low-income, or both, as well as tribal lands within the study area. Of the census block groups identified as minority populations or low-income populations, 1,225 (nearly 30 percent) are classified as both low-income and minority populations.

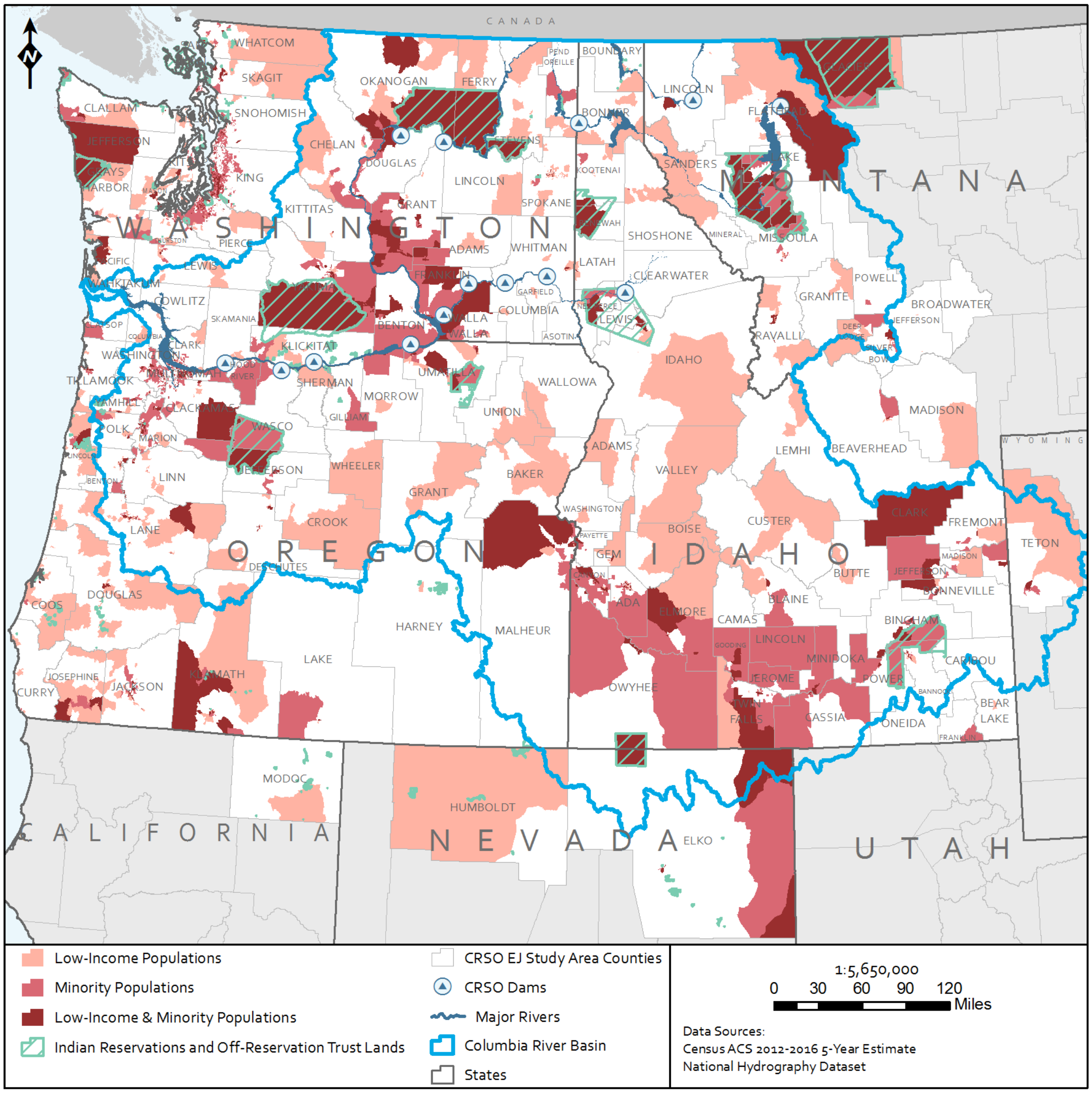


**Figure 3-232. Minority and Low-Income Populations, Indian Reservations, and Off-Reservation Trust Lands in the Study Area**

*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.

### 3.18.3 Environmental Consequences

The environmental justice analysis evaluates whether there would be disproportionately high and adverse human health or environmental effects on minority populations, low-income populations, or Indian tribes resulting from changes to resources under the MOs in accordance with E.O. 12898 and the associated guidance published by the CEQ in 1997 (CEQ 1997). While tables 6-40 and 6-41 in Chapter 6 are not duplicated within this environmental justice section, those tables provide summaries of direct, indirect and reasonably foreseeable future actions relevant to environmental justice populations which are incorporated into the analysis in this section.

#### *3.18.3.1 Resources Not Analyzed Further in this Section*

Several resources addressed in the EIS are not analyzed further in the environmental justice analysis because: the resource would not be affected or would have minimal effects across alternatives; it is readily apparent that resource effects would not be likely to disproportionately affect low-income populations, minority populations, or Indian tribes; or because the resource effects are subsumed in other resource evaluations. Effects to these resources are summarized below.

**Hydrology and hydraulics, and river mechanics.** Effects to these resources are evaluated through other resource effects (in particular, Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*; Section 3.6, *Vegetation, Wildlife, Wetlands, and Floodplains*; and Section 3.16, *Cultural Resources*).

**Water quality.** The MOs may affect water quality, which could affect public health conditions if nutrient loading, water clarity, or the level of contaminants suspended in rivers were affected. Some minority populations, low-income populations, or Indian tribes may have different or more intense use of river resources for drinking, fishing, recreating, or subsistence practices than the general population. Populations who rely on subsistence fishing in Lake Roosevelt could be negatively impacted if the bioaccumulation of heavy metals increase under MO4; this is discussed further in the context of fish resources below. Adverse effects to drinking water have not been identified in the Water Quality analysis.[8] Effects related to water quality changes were not analyzed separately in this environmental justice section because those effects are captured in the evaluation of effects to other resources, namely, Section 3.5, *Aquatic Habitat, Aquatic Invertebrates, and Fish*; Section 3.6, *Vegetation, Wildlife, Wetlands, and Floodplains*; Section 3.11, *Recreation*; Section 3.16, *Cultural Resources*; and Section 3.17, *Tribal Trust Assets, Tribal Perspectives, and Tribal Interests*.

**Vegetation, wildlife, wetlands, and floodplains.** In general, the analyses of effects to 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.

resources across most MOs. Potential adverse effects on resources are identified in Region C under MO3. Effects include changes to the types of vegetation and wildlife supported along the shoreline of reservoirs as water levels fluctuate under the MOs. These changes have the potential to adversely affect plants used for ceremonial and subsistence gathering activities by tribal populations that may occur in affected areas. Under MO3, in the short-term immediately following breach, subsistence gathering and traditional hunting and trapping activities may be affected by changes in resource availability. Upon reestablishment of vegetation communities, the target species are expected to return and be available for traditional hunting and trapping activities. Therefore, effects are anticipated to be minor with no disproportionately high and adverse effects on minority, low-income, or tribal populations.

**Air quality.** The MOs have the potential to adversely affect air quality and human health conditions, particularly under alternatives that could result in a reduction in hydropower and potential increase in fossil fuel use, which may occur under MO3 and MO4. If fossil fuel-based power generation increases, air pollutant emissions would increase. To the extent that these increases would occur near low-income, minority, or tribal populations, adverse effects to air quality in those communities could result. However, there are a number of uncertainties surrounding the likelihood, volume, and specific location of future emissions that render making a determination of effects to specific communities highly speculative at this time.

In particular, given recent and emerging regulatory and policy initiatives in the Northwest, the extent and likelihood of increased regional fossil fuel generation is uncertain, as is the location of any new sources of fossil fuel generation that could be required under the MOs.

The analyses of effects to air quality also identified minor to moderate short-term effects related to construction projects; however, given the short-term nature of these projects and the potential for best practices in construction to avoid adverse effects, the likelihood of disproportionately high and adverse effects are not expected on minority populations, low-income populations, or Indian tribes. In addition, anticipated increased air pollutant emissions associated with shifts in the mode of transporting goods under MO3 would be long term. To the extent that transportation routes and hubs are located in areas where minority populations, low-income populations, or Indian tribes are located, these populations may be affected. However, these effects would likely be small relative to total transportation-related air pollutant emissions under the No Action Alternative.

**Flood risk management.** The MOs were analyzed to determine the potential to affect flood risk in the region. However, the flood risk analysis in Section 3.9 of this EIS does not anticipate changes to flood risk from any of the MOs.

**Visual resources.** Visual effects associated with construction or modification of facilities are anticipated under various MOs. Tribal members engaging in traditional cultural practices or visiting sites may have their visual experience effected by new infrastructure associated with MOs. However, the analyses of effects to visual resources identified negligible to minor effects to these resources across most MOs. Negligible to minor adverse effects on resources were identified in Region C under MO3. In particular, local residents and visitors would experience aesthetic changes due to losses of lake-like characteristics and a return to free-flowing riverine characteristics under MO3 in the vicinity of reservoirs in the lower Snake River. However, these minor to negligible adverse effects do not appear likely to disproportionately affect minority populations, low-income populations, or Indian tribes. Indeed, certain Indian tribes in the area, such as the Nez Perce Tribe, support breaching the four lower Snake River dams.

**Noise**. The primary noise effects are expected under MO3 related to the breaching of earthen embankments and other major structural changes to the four lower Snake River projects. These short-term effects would occur in isolated areas without residences immediately nearby. While other structural measures would result in some noise effects, these are expected to be negligible to minor. The proposed MO3 operational and structural measures at Dworshak, which is within the Nez Perce Reservation, are likely to create noise effects that are similar to the NAA and would be negligible. These negligible to minor effects do not appear likely to disproportionately affect minority populations, low-income populations, or Indian tribes.

#### *3.18.3.2 Resources Analyzed Further in this Section*

For the following resources, the environmental justice analysis compares effects to the general population and effects to minority populations, low-income populations, and Indian tribes by alternative and by region and determines if disproportionately high and adverse effects may occur to EJ populations.

**Fish.** Commercial, ceremonial, and subsistence fishing activity occurs in various locations on the mainstem Columbia and Snake Rivers and in tributaries throughout the study area. The MOs have the potential to affect the availability of fish for low-income populations, minority populations and Indian tribes participating in these activities.

The river mechanics analysis indicates minor increases in the mobility of bed material in Lake Roosevelt under MO4. If contaminated slag is present in the mobilized bed material, this could create additional toxicity in fish and other aquatic organisms. However, the change in potential toxicity is unknown. Reservoir drawdowns of longer duration under MO4, increase the exposure of shorelines. Increased exposure has the potential to increase mercury methylation rates, which could lead to greater buildup of mercury quantities in aquatic organisms (i.e. bioaccumulation) (Willacker 2016). Populations who rely on subsistence fishing in Lake Roosevelt could be negatively impacted if the bioaccumulation of heavy metals increases.

**Power generation and transmission**. The MOs have the potential to place upward pressure on electricity rates. The base case methodology and cost sensitivities analysis are described in the Power Generation and Transmission section of this chapter under the environmental consequences sub-section, 3.7.3.1. The typical median household income in low-income populations, minority populations, and Indian tribes in the study area is $39,000.[9] Low-income households typically spend a larger portion of their income on home energy costs (e.g., electricity, natural gas, and other home heating fuels) than other households spend (DOE 2018). These households may also have a more difficult time adapting to a higher cost of living if annual electricity bills increase.[10] Using 6 percent as a threshold of affordability for energy, low-income households in low-income populations, minority populations, or Indian tribes (or both) in the study area could afford annual energy costs (including electricity, gas and other fuel expenditures) of approximately $2,340.[11] Anticipated rate changes for each county are illustrated graphically in the Section 3.7, *Power and Transmission*. Discussion of impacts of alternatives on transmission services and energy markets and the impacts on reliability is also included in Section 3.7, *Power and Transmission*. The potential effects of the MOs on transmission rate pressure are captured in the analysis of residential, commercial, and industrial retail rates. Upward rate pressure on commercial and industrial rates for end-users are expected to be small under MO1 and MO2. While the upward rate pressure is greater under MO3 and MO4, the potential effects on the cost of electricity as a percentage of the total costs of production of goods and services in the region would be small. Therefore, whether the potential extent to which those costs could be passed on to consumers is uncertain. Given this, if there are any effects of the MOs on the price of goods and services in the region, which is uncertain, the effects to regional consumers—including low-income populations, minority populations or Indian tribes—would be very slight.

Separately, to the extent that the volume of power sales revenue and generation at Grand Coulee Dam would change under the MOs, annual payments to the Confederated Tribes of the Colville Reservation, mandated by the Grand Coulee Dam Settlement Agreement Act of 1994, could be affected.

**Navigation and transportation**. Changes to in-river and reservoir conditions under the MOs could affect the availability of ports for commercial navigation activities (including commercial shipping barges, cruise ships, and ferries). Costs of shipping goods in the region

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[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).

may increase under some MOs. If increases in transportation costs for agricultural products grown in the area result in changes to operations, farming employment opportunities for low-income or minority farmworkers (or both) in the study area could be affected. Inchelium-Gifford Ferry operations on Lake Roosevelt could also be affected by operational measures in some MOs that would result in additional reservoir fluctuations, including earlier and/or deeper drawdowns in some years. This ferry is operated by the Confederated Tribes of the Colville Reservation and primarily serves the tribal population.

**Water supply**. The MOs have the potential to affect access to water sources, as well as the costs to supply water. Effects are focused on a need to extend pumps under MO4 to allow for continued water supply, and the potential loss of irrigation under MO3 because the pumps that supply this water would no longer be operational once the dams were breached and the nearby groundwater elevations could be adversely impacted. If the MOs affect drinking water or agricultural water sources for minority populations, low-income populations, or Indian tribes, this could affect the cost of living in an area as well as the availability of employment opportunities.

**Recreation.** Changes in river and reservoir conditions under the MOs could affect the quality and availability of recreational opportunities and associated employment opportunities for minority populations, low-income populations, and Indian tribes in the study area. However, the analyses of effects to recreation identified negligible to minor effects to these resources across most MOs. Adverse effects on resources are identified in Region C under MO3. In addition, localized adverse effects for recreational fishing may exist along the Clearwater River in Region C in August and September under MO1.

**Cultural resources.** The MOs have the potential to affect cultural resources (including archaeological resources, TCPs, historic built resources, and sacred sites) as a result of changes in reservoir elevations or construction activities. Natural and cultural resources associated with the Columbia River Basin are of critical importance to Indian tribes in the region for subsistence, commerce, preservation of cultural traditions and history, religious practice, and self-determination as sovereign nations. Indian tribes in the Columbia River Basin continue to rely on the river, its tributaries, and surrounding areas for fishing, hunting, gathering, and conducting traditional and religious ceremonies. In particular, fish are an important component in the health of tribal members in the Northwest. To date, hundreds of Traditional Cultural Properties (TCPs), multiple built historic resources, and over 4,500 archaeological sites have been recorded in the area of potential effects for the 14 CRS projects (FCRPS 2018). Two sacred sites were identified in the study area: Bear Paw Rock and Kettle Falls (please see Section 3.16.2.7 for additional information). As discussed in Section 3.16, Cultural Resources, ongoing effects of inundation and reservoir fluctuation would continue to have major adverse effects on TCPs under the No Action Alternative. Implementation of the MOs could negatively affect cultural resources through increasing exposure and erosion associated with increased reservoir level fluctuations. In addition to increasing the potential for damage and decay due to erosion, increased exposure can create the potential for effects associated with public access including looting, vandalism, creation of trails, and unauthorized activities. Indian Trust Assets are analyzed in Section 3.17 of this EIS.

### *3.18.3.3 Effects Assessment Methodology*

In order to determine whether environmental effects are disproportionately high and adverse on minority populations, low-income populations, or Indian tribes, CEQ in its "*Environmental Justice, Guidance Under the National Environmental Policy Act*" guides agencies to consider the following three factors:

Whether there would be a "significant" (as defined by NEPA) ecological, cultural, human health, economic, or social impact that would adversely affect a minority population, low-income population, or Indian tribe.

Whether "significant" (as defined by NEPA) effects on a minority population, low-income population, or Indian tribe may appreciably exceed those experienced by the general population.

Whether cumulative or multiple adverse exposures from environmental hazards would affect a minority population, low-income population, or Indian tribe (CEQ 1997).

To evaluate these factors, the analysis followed these general steps:

Identify populations that are considered to be environmental justice populations (presented in Section 3.15.2.4).

Identify whether the MOs would result in direct, indirect or cumulative (i.e. past, present or reasonably foreseeable future as described in Chapter 6) resource effects to minority populations, low-income populations, or Indian tribes.

Assess and describe the nature and relative intensity (e.g., magnitude) of resource effects that would be borne by the general population and compare those effects to the effects to minority populations, low-income populations, or Indian tribes. Consider relevant factors that may amplify effects to minority populations, low-income populations, or Indian tribes.

Summarize moderate and major effects by each MO and consider the effect of incorporating mitigation identified for each MO.

For each alternative, identify if there are any disproportionately high and adverse effects on minority populations, low-income populations, or Indian tribes.

This section presents the likely EJ finding for each MO and includes consideration of direct and indirect effects in Chapter 3, climate effects described in Chapter 4, mitigation described in Chapter 5, and cumulative effects described in Chapter 6. Chapters 7 and 8 provide the EJ finding for the Preferred Alternative.

While beneficial environmental justice effects to resources may occur within MOs, those beneficial effects are generally not discussed in this analysis, except when beneficial effects could minimize adverse effects.

### *3.18.3.4 No Action Alternative*

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

Approximately 40 percent of the census block groups in Region A are classified as low-income or minority or both. Low-income and minority block groups are located near Albeni Falls and Hungry Horse Dams. There are also a number of Indian tribes with reservation lands and off-reservation trust lands in Region A, including the Kootenai Tribe of Idaho, the Confederated Salish and Kootenai Tribes, and the Kalispel Tribe of Indians. The following resource effects would occur in Region A under the No Action Alternative, affecting minority populations, low-income populations, or Indian tribes:

**Fish.** This EIS assumes that ceremonial and subsistence fishing activities for Indian tribes as well as other subsistence fishers, including minority and low-income populations, would be relatively consistent with current levels under the No Action Alternative. The Kootenai Tribe of Idaho relies heavily on subsistence fishing; the Kootenai River itself is part of the Tribe's identity and a number of historical fishing camp locations occur along the River. Fish are also an important component in the health of tribal members. Research indicates that loss of traditional food sources may put indigenous people at greater risk for a variety of diet-related illnesses. According to a 1994 CRITFC study, fish consumption is higher among the four Lower River treaty tribes than the general public. Some low-income and minority populations may participate in subsistence fishing throughout the region.

**Power generation and transmission.** The average annual cost of electricity per household in Region A under the No Action Alternative would range from approximately $750 to $1,500, depending on the county. Figure 3-233 illustrates the energy burden for households below the poverty level in low-income communities, minority communities, as well as on Indian tribal lands in Region A. As shown, the current total energy burden for these areas ranges from 9 to 22 percent for households.[12] In contrast, households above the poverty level have energy burdens that range from 2 to 4 percent in Region A (DOE 2016). As noted above, energy burdens above 6 percent can be considered unaffordable. As such, low-income communities, minority communities, and Indian tribes, and particularly low-income households in these communities, already experience potentially unaffordable energy burdens under the No Action Alternative in Region A. Any upward rate pressure in this region could impact low-income households for whom energy costs are a larger percent of their income. In some cases, these low-income households are also minority, tribal, or both, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse.

[12] LEAD is reported at the Census tract level, which is a larger unit that the census block groups used to identify these populations. Census tract level data is used to characterize these populations.

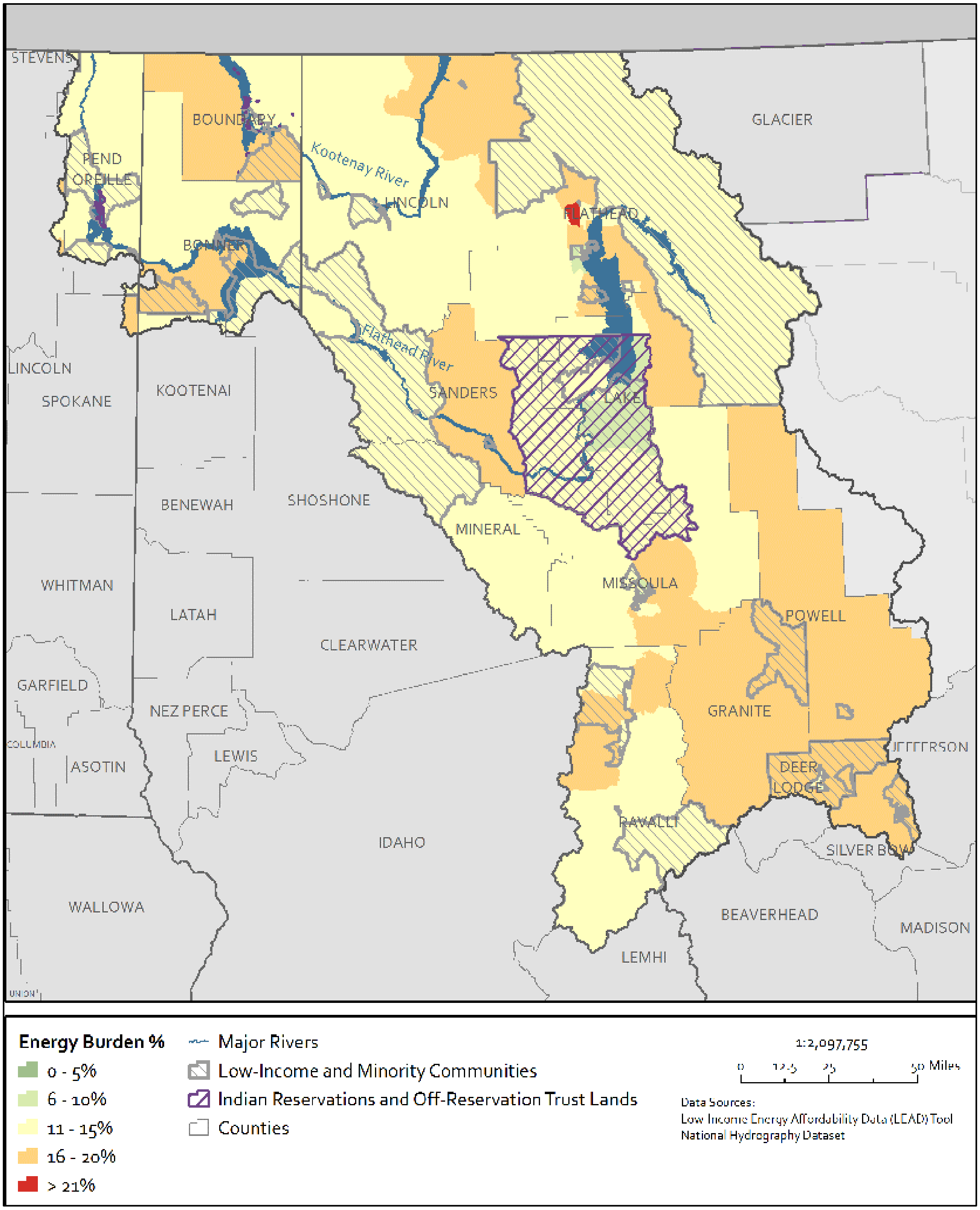


**Figure 3-233. Percent of Household Income Spent on Energy (Energy Burden) for Households Below Poverty Level – Region A**

**Navigation and transportation.** Commercial navigation, cruise ships, and ferries do not occur in Region A. This would not change under the No Action Alternative. Navigation and transportation is not discussed further in Region A for any alternative.

**Water supply**. Municipal and industrial and irrigation would not be affected in Region A under any alternative and is not discussed further in Region A for any alternative.

**Recreation**. As described in the Recreation section, in Region A, total recreational visitation under the No Action Alternative is anticipated to be approximately 1.5 million visits annually, primarily associated with visitation at Hungry Horse, Libby and Albeni Falls/Lake Pend Oreille. There are a number of minority, low-income, or Tribal populations in Region A that may engage in recreational activities and reside in proximity to the affected recreation sites, including the Confederated Salish and the Kootenai Tribes of the Flathead, Kalispel Tribe, Coeur D'Alene Tribe, and the Blackfeet Tribe of the Blackfeet Indian Reservation of Montana. Visitation to recreation areas also supports employment and spending in local areas around the recreation sites. The average annual regional economic contribution of recreational activity in terms of jobs and output is described in the Recreation section.

**Cultural resources.** As detailed in Section 3.16.2.6., numerous traditional cultural properties are present in the vicinity of projects in Region A. No traditional cultural properties were identified at the Libby Project due to the co-lead agencies having no geospatial data. In addition, Bear Paw Rock has been identified as a sacred site affected by operations of Albeni Falls. Traditional cultural properties and the Bear Paw Rock sacred site would continue to be adversely affected under the No Action Alternative due to ongoing operations and maintenance of the Columbia River System.

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

Approximately 45 percent of census block groups in Region B are classified as low-income populations, minority populations, or both. Low-income and minority block groups are located near the Grand Coulee and Chief Joseph Projects. There are also a number of Indian tribes with reservation lands and off-reservation trust lands in Region B, including the Confederated Tribes of the Colville Reservation (CTCR), the Spokane Tribe of Indians, and the Coeur d'Alene Tribe. A variety of ongoing activities would occur in Region B under the No Action Alternative that have the potential to affect minority populations, low-income populations, or Indian tribes. These include the following:

**Fish.** A recreational fishery for Okanogan sockeye occurs in Region B. Kokanee, redband rainbow trout, white sturgeon, and burbot are important resources to the Indian tribes in Region B. Also rainbow trout are raised for release in tribal and recreational fisheries. Wild anadromous fish can access the Wenatchee, Entiat, and Methow watersheds in the upper Columbia River and tribes have been working to restore Pacific lamprey populations. This EIS assumes that ceremonial and subsistence fishing activities for Indian tribes as well as other subsistence fishers, including minority and low-income populations, would be relatively consistent with current levels under the No Action Alternative. Fish are also an important component in the health of tribal members. Research indicates that loss of traditional food sources may put indigenous people at greater risk for a variety of diet-related illnesses. According to a 1994 CRITFC study, fish consumption is higher among the four Lower River treaty tribes than the general public. Some low-income and minority populations may participate in subsistence fishing throughout the region.

**Power generation and transmission.** The average annual cost of electricity per household in Region B under the No Action Alternative would range from $310 to $1,100 depending on the county. Figure 3-234 illustrates the energy burden for households below the poverty level in low-income communities, minority communities, as well as on Indian tribal lands in Region B. As shown, the current total energy burden for these areas ranges from 5 to 27 percent for households. In contrast, households above the poverty level have energy burdens that range from 1 to 4 percent Region B (DOE 2016). As noted above, energy burdens above 6 percent can be considered unaffordable. As such, low-income communities, minority communities, and Indian tribes, and particularly low-income households in these communities, already experience potentially unaffordable energy burdens under the No Action Alternative in Region B. Any upward rate pressure in this region could impact low-income households, for whom energy costs are a larger percent of their income, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal or both. The CTCR also receive annual payments under the Grand Coulee Settlement Agreement based on Bonneville power sales revenue and generation at Grand Coulee Dam, which is anticipated to continue under the No Action Alternative. The Spokane Tribe of Indians will also begin to receive annual payments in 2021 which would continue under the No Action Alternative.

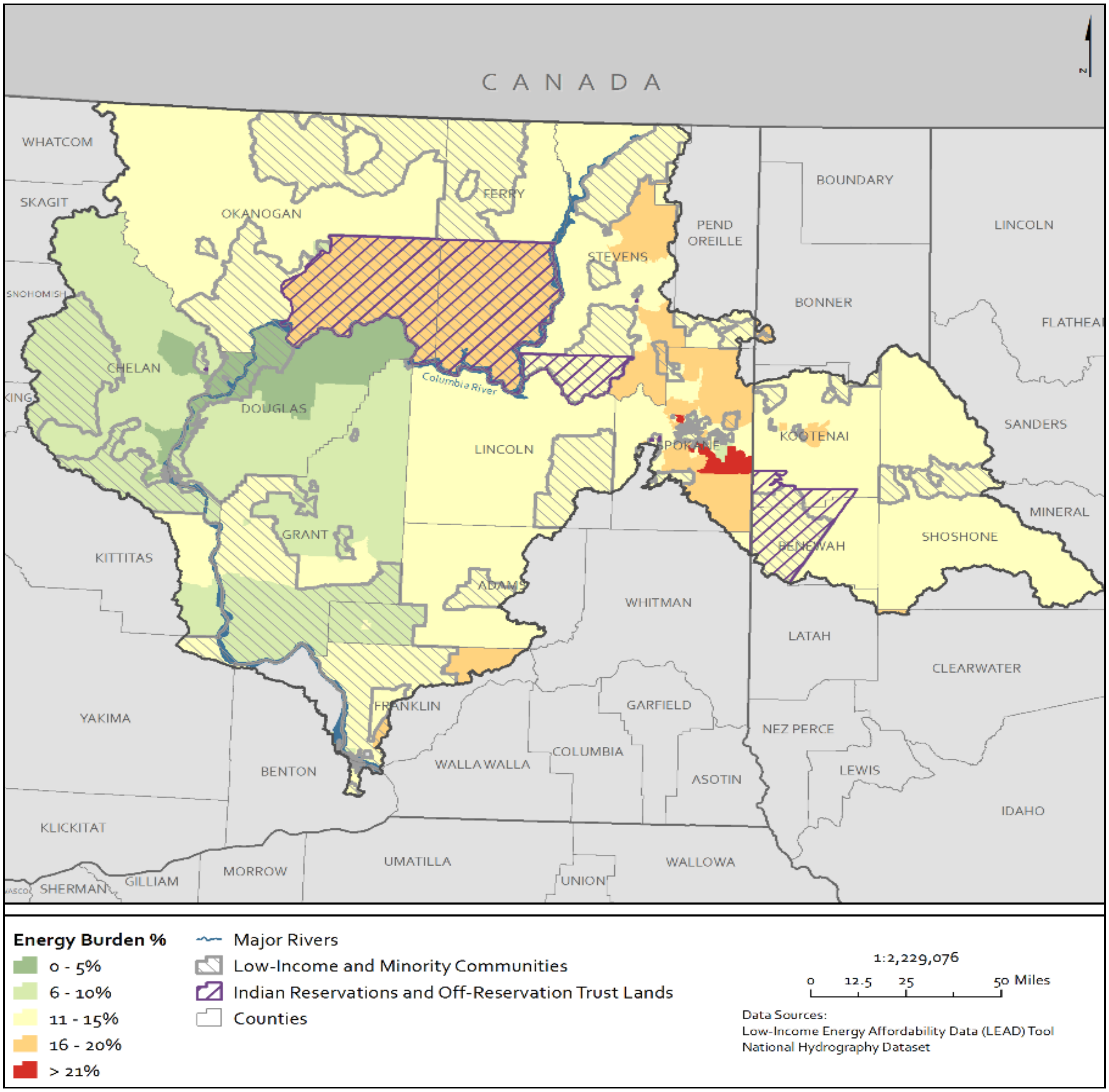


**Figure 3-234. Percent of Household Income Spent on Energy (Energy Burden) for Households Below Poverty Level – Region B**

**Navigation and transportation.** The Inchelium-Gifford Ferry is operated by the CTCR, and provides commuters, schoolchildren, tourists, and others with transportation for daily activities including commuting to work, accessing health care, and participating in educational activities. Under the No Action Alternative, reservoir elevations would be expected to allow ferry operations throughout the year in typical years, but would be unable to operate for approximately 27 days per year in wet years because the reservoir is drawn down to accommodate flood waters below 1,229 feet to make space available in the reservoir for flood risk management (Section 3.10, *Navigation and Transportation*).[13] When the ferry is not in service, the next nearest Columbia River crossing is approximately 34 miles to the north on WA20/US395 and WA25/US395.

**Water supply**. Municipal and industrial and irrigation would not be affected in Region B under any alternative and is not discussed further in Region B for any alternative.

**Recreation.** As described in the Recreation section, in Region B, total recreational visitation under the No Action Alternative is anticipated to be around 2.0 million visits annually on average, primarily associated with visitation near Grand Coulee Dam (Lake Roosevelt) and Chief Joseph Dam (Lake Rufus Woods). There are a number of minority, low-income, or Tribal populations in Region B that may engage in recreation and reside in proximity to the affected recreation sites, including the Confederated Tribes of the Colville Reservation and the Spokane Tribe of Indians. Visitation to recreation areas also supports employment and spending in local areas around the recreation sites. The average annual regional economic contribution of recreational activity in terms of jobs and output is described in the Recreation section.

**Cultural resources.** As detailed in Section 3.16.2.6., numerous traditional cultural properties are present in the vicinity of projects in Region B. In addition, Kettle Falls has been identified as a sacred site affected by operations of Grand Coulee. Traditional cultural properties and the Kettle Falls sacred site would continue to be adversely affected under the No Action Alternative due to ongoing operations and maintenance of the Columbia River System.

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

Approximately one-third of the census block groups in Region C are classified as low-income or minority or both. Low-income and minority census block groups are located near the Ice Harbor, Lower Monumental, and Dworshak Projects. The Nez Perce Tribe has reservation and off-reservation trust lands in Region C, including an area overlapping with Dworshak. A variety of ongoing activities would occur in Region C under the No Action Alternative that have the potential to affect minority populations, low-income populations, or Indian tribes. These include the following:

**Fish.** Under the No Action Alternative, ceremonial and subsistence fishing activity is assumed to be relatively consistent with current levels. Ceremonial and subsistence fishing, particularly for salmon, steelhead, lamprey, and white sturgeon, is an important cultural, economic, and spiritual practice for Indian tribes from the Pacific Coast to the Puget Sound and even the Inland Northwest (PFMC 1999) Salmon is considered vital to the Nez Perce way of life and 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 (NAVGD29) was identified through communications with ferry operators at the Colville Tribe (July 9, 2019).

Hall Indian Reservation also tie the fate of salmon to the existence of their culture. Pacific lamprey is also important to the Nez Perce and other Indian tribes and has been impacted by the mainstem Columbia and Snake River dams. The four lower River treaty tribes (Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakama Nation), as well as state and Federal agencies, are currently working to restore and protect lamprey populations in the region (CRITFC 2019). This EIS assumes that ceremonial and subsistence fishing activities for Indian tribes as well as other subsistence fishers, including minority and low-income populations, would be relatively consistent with current levels under the No Action Alternative.

**Power generation and transmission.** The average annual cost of electricity per household in Region C under the No Action Alternative would range from $880 to $1,100, depending on the county. Figure 3-235 illustrates the energy burden for households below the poverty level in low-income communities, minority communities, as well as on Indian tribal lands in Region C. As shown, the current total energy burden for these areas ranges from 7 to 19 percent for these households. In contrast, households above the poverty level have energy burdens that range from 2 to 3 percent in Region C (DOE 2016). As noted above, energy burdens above 6 percent can be considered unaffordable. As such, low-income communities, minority communities, and Indian Tribes, and particularly low-income households in these communities, already experience potentially unaffordable energy burdens under the No Action Alternative in Region C. Any upward rate pressure in this region could impact low-income households, for whom energy costs are a larger percent of their income. In some cases, these low-income households are also minority, tribal, or both, but these impacts would occur across the region at level that would not be considered disproportionately high and adverse.

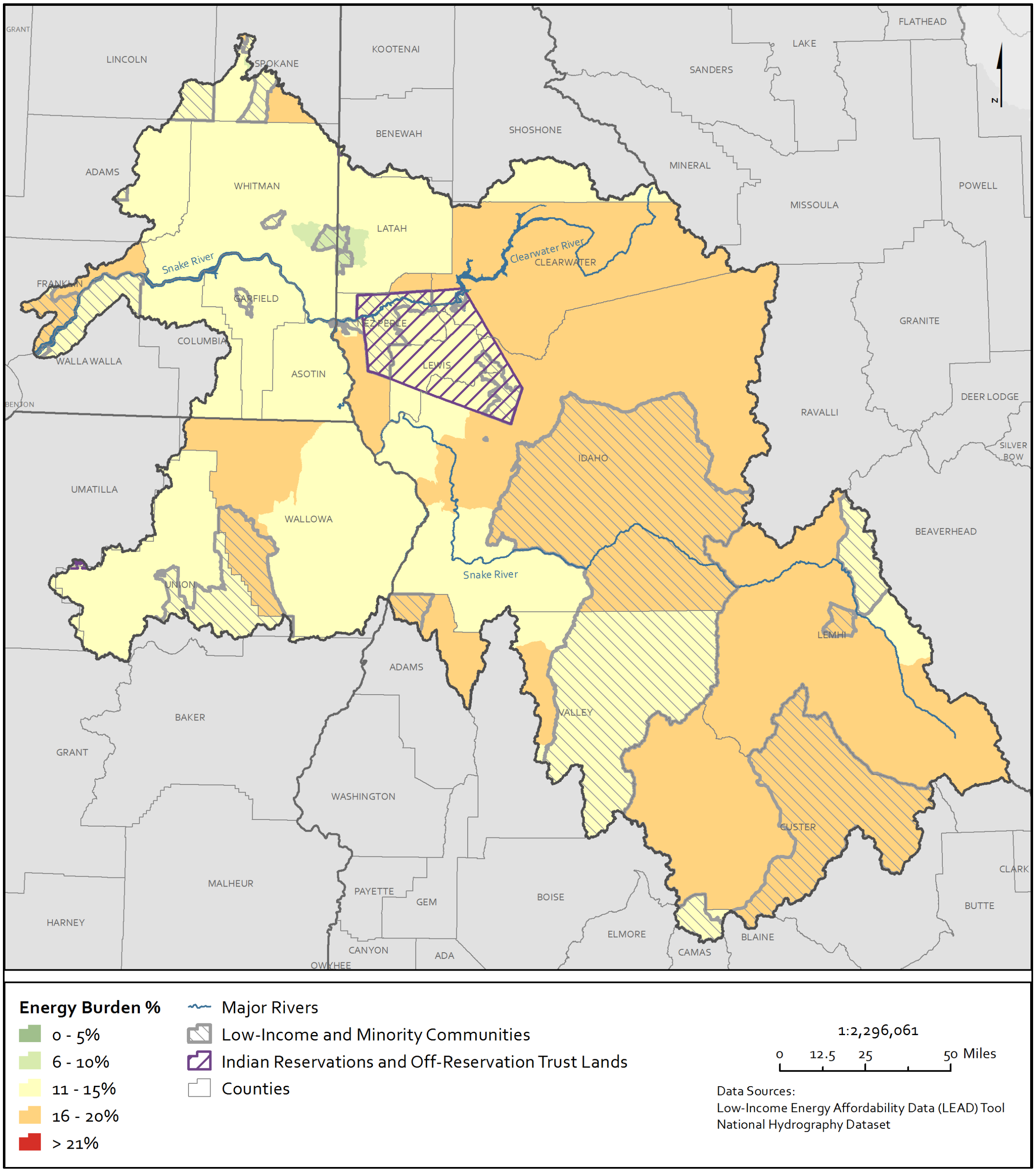


**Figure 3-235. Percent of Household Income Spent on Energy (Energy Burden) for Households Below Poverty Level - Region C**

**Navigation and transportation.** Wheat farming occurring in Region C benefits from the availability of low-cost barge transportation on the lower Snake and lower Columbia Rivers, which allows for economical shipping of commodities from this region. Ports located along the Snake River provide important development hubs for communities and help drive economic development in the region. In addition, commercial activity associated with cruise ships is growing and brings visitors and tourist dollars to the municipalities along the river. Low-income and minority populations would benefit to some degree from tourism and employment from these activities under the No Action Alternative. Cruise ships typically board in the Portland area and travel downstream to Astoria as well as up the mainstem Columbia to departure points on the lower Snake River, typically near Clarkston, Washington. While cruise ship activity would be affected under MO3, effects of this change are not anticipated to be borne disproportionately by minority populations, low-income populations, or Indian tribes. The six cruise ships serving the Columbia River likely draw employees from the greater Portland area, and there is no evidence to suggest these employees are predominantly from environmental justice populations. As such, effects to cruise ships is not addressed further in this analysis.

**Water supply.** As described in Section 3.12, *Water Supply*, three counties in Region C draw on surface water and groundwater for municipal and industrial use along the Snake River. Changes to the operations of Federal projects could affect access to diversions in these counties as well as the costs to deliver water. In addition, approximately 48,000 acres would be irrigated in counties along the Columbia River under the No Action Alternative in Region C. Based on unemployment claims for Washington State, the number of minority farmworkers in counties in the Ice Harbor and Lower Monumental water supply socioeconomic region is very small (less than 0.1 percent Hispanic) (WAESD 2019). In addition, less than 3 percent of farm producers (i.e., persons who are involved in making decisions for the farm operation) in these counties in Region C are Hispanic (NASS 2017).

**Recreation.** As described in the Recreation section, total recreational visitation under the No Action Alternative in Region C is anticipated to be approximately 3.0 million visits annually, primarily associated with visitation at Lower Granite Dam and Reservoir, located near Lewiston, Idaho. The Nez Perce Tribe in Region C may engage in recreational activities in proximity to the affected recreation sites. Visitation to recreation areas also supports employment and spending in local areas around the recreation sites. The average annual regional economic contribution of recreational activity in terms of jobs and output is described in the Recreation section.

**Cultural resources.** As detailed in Section 3.16.2.6., numerous traditional cultural properties are present in the vicinity of projects in Region C. Traditional cultural properties would continue to be adversely affected under the No Action Alternative due to ongoing operations and maintenance of the Columbia River System.

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

Approximately 45 percent of census block groups in Region D are classified as low-income or minority or both. Low-income and minority block groups are located near the McNary, John Day, The Dalles, and Bonneville Projects. There are also a number of Indian tribes with reservation lands and off-reservation trust lands in Region D, including the Confederated Tribes and Bands of the Yakama Nation, the Cowlitz Indian Tribe, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes of the Umatilla Indian Reservation. A number of other Indian tribes also use Region D for fishing activities. Additional anadromous fish species discussed in Regions B and C also contribute to tribal fisheries in Region D. A variety of ongoing activities would occur in Region D under the No Action Alternative that have the potential to affect minority populations, low-income populations, or Indian tribes. These include the following:

**Fish**. Under the No Action Alternative, commercial, ceremonial and subsistence fishing activities are assumed to be relatively consistent with current levels. Ceremonial and subsistence fishing, particularly for salmon, steelhead, lamprey, and white sturgeon, is an important cultural, economic, and spiritual practice for Indian tribes from the Pacific Coast to the Puget Sound and even the Inland Northwest (PFMC 1999). Ceremonies represent the interdependence of all living things and demonstrate respect for the fish, both as living beings and a source of subsistence (PFMC 1999). Along the mainstem Columbia River, most tribal commercial fisheries occur between Bonneville and McNary Dams, in the "Zone 6" fishery. Tribal commercial salmon catch within Zone 6 of the Columbia River was valued at $6.1 million in 2017 (PFMC 2018).[14] Commercial fishing is an important source of income for some members of the Indian tribes in this region (NMFS 2014). Ceremonial and subsistence fishing take priority over commercial fishing. If a harvest is not sufficient for ceremonial and subsistence needs, fish will be taken from the commercial fishery stock to cover the deficit (NOAA 2018). The four Lower River treaty tribes (Nez Perce Tribe, Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Confederated Tribes and Bands of the Yakama Nation), as well as State and Federal agencies, are currently working to restore and protect lamprey populations in the region(CRITFC 2019). Fish are also an important component in the health of tribal members. Research indicates that loss of traditional food sources may put indigenous people at greater risk for a variety of diet-related illnesses. According to a 1994 CRITFC study, fish consumption is higher among the four Lower River treaty tribes than the general public. Some low-income and minority populations may participate in subsistence fishing throughout the region.

**Power generation and transmission.** The average annual cost of electricity per household in Region D under the No Action Alternative would range from $700 to $1,200, depending on the county. Figure 3-236 illustrates the energy burden for households below the poverty level in low-income communities, minority communities, as well as on Indian Tribal lands in Region D. As shown, the current total energy burden for these areas ranges from 5 to 23 percent for households. In contrast, households above the poverty level have energy burdens that range from 1 to 4 percent Region D (DOE 2016). As noted above, energy burdens above 6 percent can be considered unaffordable. As such, low-income communities, minority communities, and Indian tribes, and particularly low-income households in these communities, already experience potentially unaffordable energy burdens under the No Action Alternative in Region D. Any upward rate pressure in this 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.

their income. In some cases, these low-income households are also minority, tribal, or both but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse.

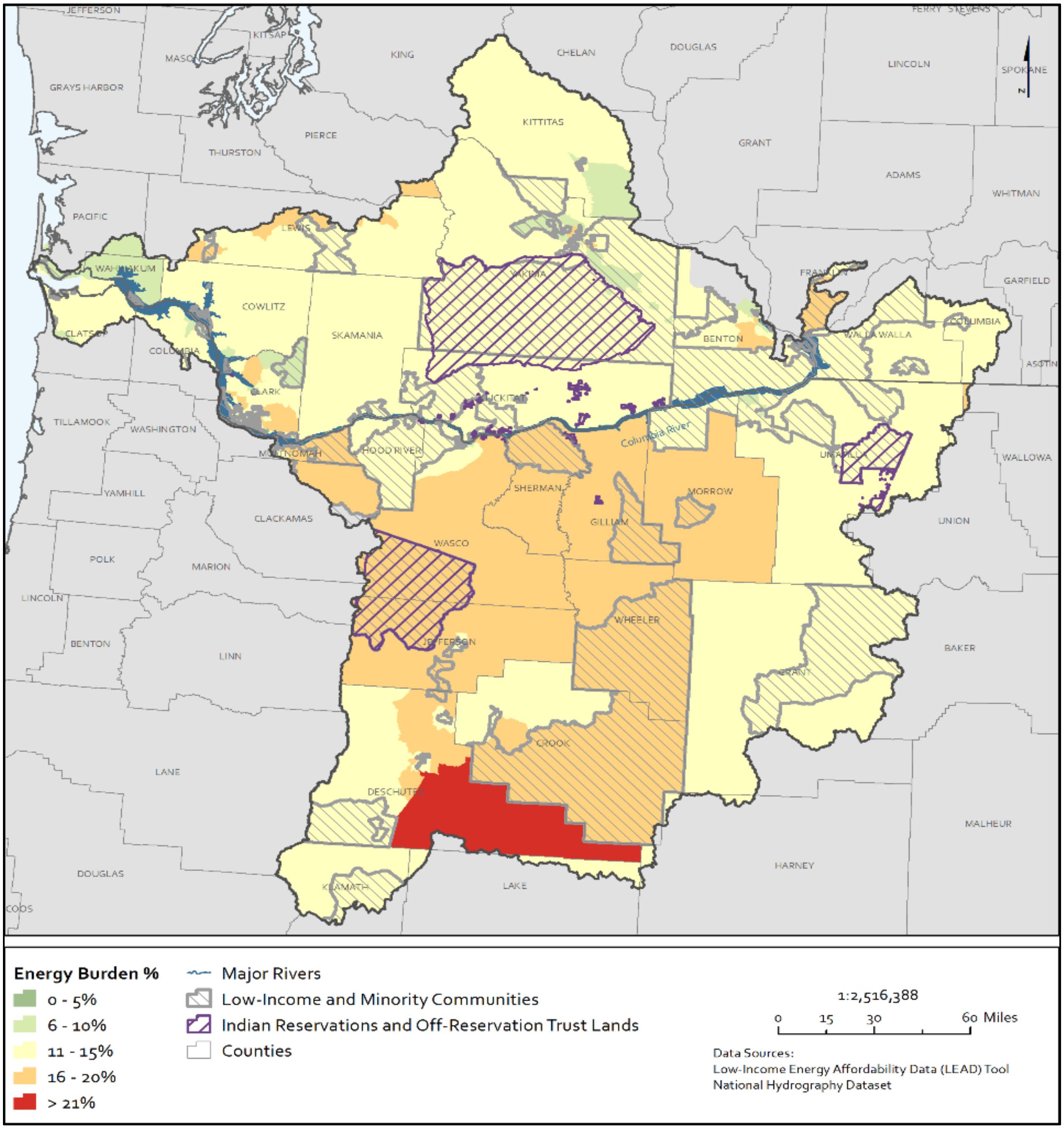


**Figure 3-236. Percent of Household Income Spent on Energy (Energy Burden) for Households Below Poverty Level - Region D**

**Navigation and transportation**. Wheat farming occurring in Region D benefits from the availability of low-cost barge transportation which allows for economical shipping of commodities, particularly grains, fuel, and chemicals. Shallow ports near the Tri-Cities area as well as large deep-water ports located along the lower Columbia River below Bonneville Dam provide important development hubs for communities and help drive economic development in this region. Cruise ships typically board in the Portland area and travel downstream to Astoria as well as up the mainstem Columbia to departure points on the lower Snake River, typically near Clarkston, Washington. While cruise ship activity passing through Region D would be affected under MO3, effects of this change are not anticipated to be borne disproportionately by minority populations, low-income populations, or Indian tribes.

**Water supply:**

- **Municipal and industrial use**. As described in Section 3.12, *Water Supply*, three counties in Region D draw on surface water and groundwater for municipal and industrial use along the Columbia River. The operations of Federal projects would continue to provide access to diversions in these counties under the No Action Alternative for municipal and industrial use.

- **Irrigated farmland.** As described in Section 3.12, *Water Supply*, approximately 289,000 acres are irrigated in counties along the Columbia River. Unemployment filings in 2018-19 in Washington suggest that approximately 73 percent of farmworkers in Region D are Hispanic (WAESD 2019). Approximately 11,600 jobs in Region D (in the John Day water supply socioeconomic area) would be supported by irrigated agriculture in Region D under the No Action Alternative.

**Recreation**. As described in the Recreation section, total recreational visitation under the No Action Alternative in Region D is anticipated to be approximately 6.7 million visits annually, primarily associated with visitation at Lake Wallula, Lake Celilio, and Lake Bonneville. The tribes located in Region D may engage in recreational activities in proximity to the affected recreation sites. Visitation to recreation areas also supports employment and spending in local areas around the recreation sites. The average annual regional economic contribution of recreational activity in terms of jobs and output is described in the Recreation section.

**Cultural resources.** As detailed in Section 3.16.2.6., numerous traditional cultural properties are present in the vicinity of projects in Region D. Traditional cultural properties would continue to be adversely affected under the No Action Alternative due to ongoing operations and maintenance of the Columbia River System.

**OTHER – AREAS OUTLIDE OF REGIONS A, B, C, AND D**

As discussed in Section 3.15.1.2, the study area for the environmental justice analysis includes areas outside of Regions A, B, C, and D, where minority populations, low-income populations, or Indian tribes may be affected by the MOs. These primarily include the Bonneville service area, where effects may occur related to changes to hydropower operations or rates or both.

**Power generation and transmission.** The average annual cost of electricity per household in the other areas (areas outside of Regions A–D but which may be affected by the MOs) would range from $630 to $1,500 depending on the county. Figure 3-237 illustrates the energy burden for households below and above the poverty level in other areas. As shown, the current energy burden by census tract ranges from 5 to 48 percent for households below the Federal poverty level versus 1 to 4 percent for households above the Federal poverty level in other areas (DOE 2016). As noted above, energy burdens above 6 percent can be considered unaffordable. As such, most low-income households in other areas already experience potentially unaffordable energy burdens under the No Action Alternative. Any upward rate pressure in other areas could impact low-income households for whom energy costs are a larger percent of their income. In some cases, these low-income households are also minority, tribal, or both, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse.

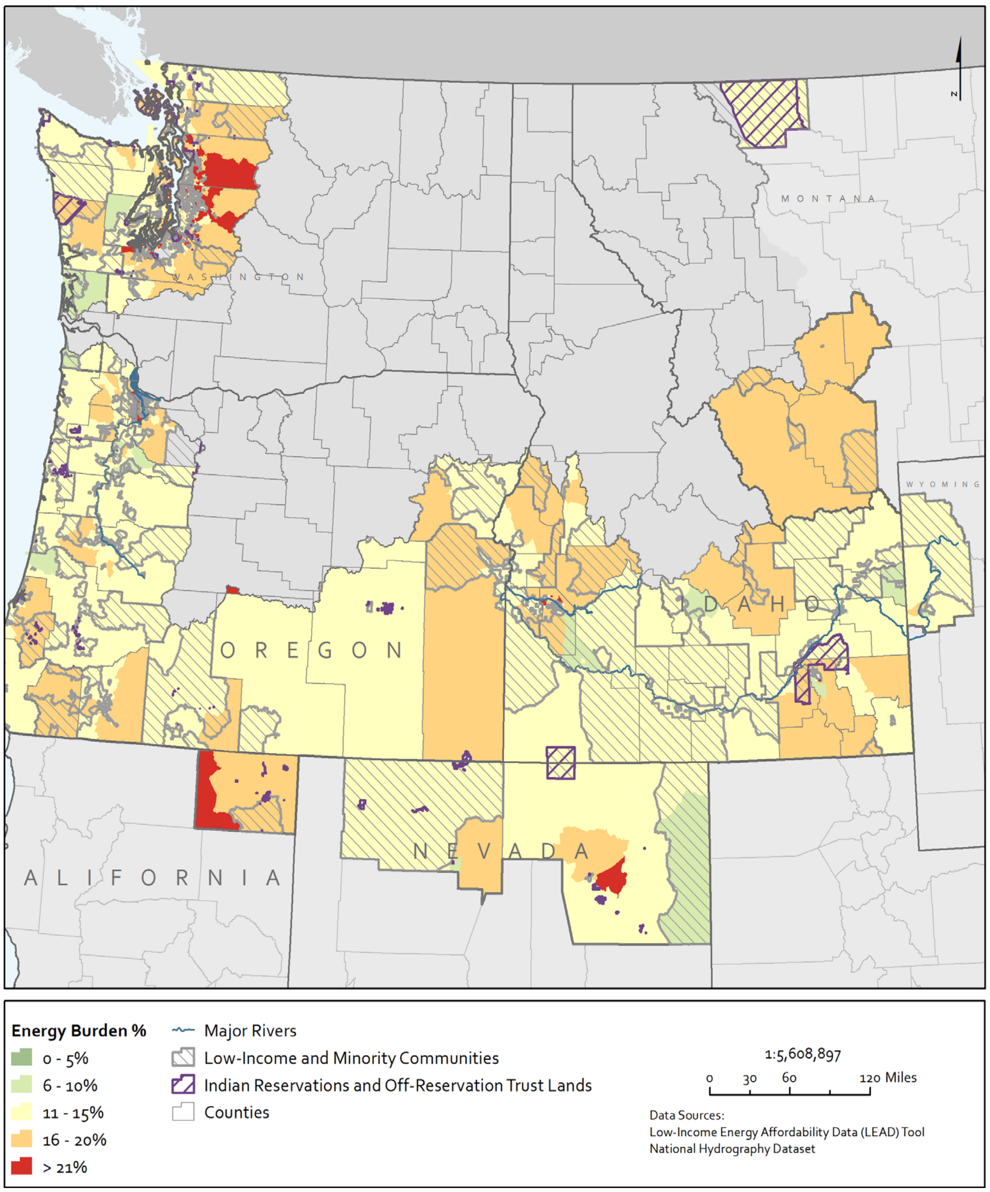


**Figure 3-237. Percent of Household Income Spent on Energy (Energy Burden) for Households Below Poverty Level – Other Areas**

**SUMMARY OF EFFECTS—NO ACTION ALTERNATIVE**

Under the No Action Alternative, effects from ongoing Columbia River System (CRS) operations on minority populations, low-income populations, and Indian tribes would continue. These ongoing impacts include the following:

Ceremonial and subsistence fishing activities for Indian tribes as well as other subsistence fishers would be relatively consistent with current levels under the No Action Alternative throughout Regions A, B, C and D. Commercial fishing in Region D under the No Action Alternative would also be expected to be relatively consistent with current levels. Adverse effects associated with the absence or reduced levels of fish due to the operation and maintenance, or existence, of the CRS would continue under the No Action Alternative. Fish are an important component of the health of tribal members. Research indicates that loss of traditional food sources may put tribal community members at greater risk for a variety of diet-related illnesses. As described in Section 3.18.2, Tribal Perspectives, the construction of the dams and current system operations have ongoing effects on tribal culture, lifeways (e.g., customs and practices), and traditions. The loss of foundational aspects of tribal culture resulting from the inundation of important fishing sites and the reduction in wild salmon populations has adversely affected tribal communities.

Low-income communities, minority communities, and Indian tribes, already experience potentially unaffordable energy burdens under the No Action Alternative throughout the study area; this is expected to continue under the No Action Alternative.

Withdrawals of surface water and groundwater for municipal and industrial use along the Columbia River in Regions C and D are not expected to change under the No Action Alternative. Irrigated agriculture and associated employment would be expected to continue at existing levels along the Columbia River under the No Action Alternative in Regions C and D.

Cultural resources in all regions would continue to be adversely affected under the No Action Alternative due to ongoing effects of inundation and reservoir fluctuation related to operations and maintenance of the CRS under the No Action Alternative.

### *3.18.3.5 Multiple Objective Alternative 1*

Adverse effects related to the following resources may occur under MO1 depending upon the region: water quality, residential and anadromous fish, power generation and transmission, navigation and transportation, recreation and cultural resources. The effects of MO1 on environmental justice populations resulting from changes in these resources are described below by region. Note, the co-lead agencies engage in ongoing actions to improve conditions for fish, which include, but are not limited to, habitat restoration, hatcheries, invasive species control, and predator management. In addition to the resources identified under Section 3.15.3.1, effects related to water supply on low-income, minority, and Indian tribes are anticipated to be negligible under MO1 because MO1 does not have any measures that would affect the ability to deliver water to meet current water supply.

## REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region A under MO1 relative to the No Action Alternative, as follows:

**Fish.** MO1 would have minor to moderate adverse effects to bull trout and Kootenai River white sturgeon, including adverse effects to food webs, varial zone at the mouth of tributaries that are important for migration, and habitat in Region A. Adverse effects on resident fish, including burbot, have the potential to adversely impact fishing opportunities in Region A for Indian tribes, and potentially other minority or low-income subsistence fishers in the Region.

MO1 mitigation includes:

- Plant 1- to 2-gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity. This would benefit ESA-listed Kootenai River White Sturgeon (KRWS) by providing a food source and complement ongoing habitat actions already being taken in the region.
- On the Hungry Horse Reservoir, install structural components like woody debris and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone to minimize effects of reservoir fluctuation where the tributaries enter the reservoir.
- On the Kootenai River, downstream of Libby, plant native wetland and riparian vegetation up to 100 acres along the river.
- Update and implement Invasive Plant Management Plan for the shoreline at Libby.

**Power generation and transmission.** Under MO1 upward or downward rate pressure may result in a change in the average annual cost of electricity per household in Region A ranging from a decrease of 0.21 percent to an increase of 3.1 percent compared to the No Action Alternative, or up to approximately $28 per year compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.035 percent of household income compared to an increase of 0.020 percent for other households in Region A. As discussed in the No Action Alternative, energy burdens in Region A are already likely unaffordable for most households with incomes below the Federal poverty level. Any downward rate pressure may be helpful for low-income households; however, energy burdens would likely remain unaffordable. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Navigation and transportation.** Commercial navigation, cruise ships, and ferries do not occur in Region A, thus no effects on navigation and transportation are anticipated to in Region A under MO1.

**Recreation.** A less than one percent change in annual water-based recreation visitation due to effects on boat ramp accessibility at Hungry Horse Reservoir and Lake Koocanusa could occur under MO1; thus, any impacts are expected to be negligible.

**Cultural resources**. Effects to traditional cultural properties to projects within Region A appear to be minor at Hungry Horse. These effects are related to increase exposure and amplitude of reservoir elevation changes relative to the NAA. No change to traditional cultural properties relative to the NAA is expected at Albeni Falls. The Bear Paw Rock sacred site would experience no change relative to the NAA. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

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

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region B under MO1 relative to the No Action Alternative, as follows:

**Fish.** MO1 would range from negligible and minor, to localized moderate adverse effects to resident fish (kokanee, redband rainbow trout, white sturgeon, and burbot) in Lake Roosevelt stemming from increased entrainment, kokanee and burbot egg stranding, and varial zone effects at the mouth of tributaries that are important for migration. There would be minor adverse effects due to reduction in sturgeon recruitment in Region B. Adverse effects on resident fish have the potential to adversely impact fishing opportunities in Region B for Indian tribes, as well as other minority or low-income subsistence fishers in the Region. Effects to Indian tribes based on changes in salmon and steelhead abundance in Region B below Chief Joseph Dam are expected to be negligible compared to the No Action Alternative.

MO1 mitigation includes developing additional spawning habitat at Lake Roosevelt to minimize impacts to non-listed resident fish.

**Power generation and transmission**. Under MO1 the upward or downward rate pressure may result in a change in the average annual cost of electricity per household in Region B ranging from a decrease of 0.48 percent to an increase of 4.2 percent compared to the No Action Alternative, or up to approximately $41 per year compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.037 percent of household income compared to an increase of 0.020 percent for other households in Region B. As discussed in the No Action Alternative, energy burdens in Region B are already likely unaffordable for most households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both. Payments to the CTCR, which are based on Bonneville power sales revenue and generation at Grand Coulee Dam, are expected to increase up to approximately 1 percent. The Spokane Tribe of Indians will also begin receiving payments based on Bonneville power sales revenue and generation at Grand Coulee Dam.

That payment is expected to begin in 2021 and under MO1 is expected to increase up to approximately 1 percent.

**Navigation and transportation**. Ferry operations on Lake Roosevelt could be affected under MO1 due to anticipated drawdowns. In wet years, when Lake Roosevelt's draw down for flood risk management begins sooner than for the No Action Alternative, the Inchelium-Gifford Ferry on Lake Roosevelt would not be able to operate for approximately 36 days of the year, which is nine additional days than anticipated under the No Action Alternative in wet years at this location. The Inchelium-Gifford Ferry is operated by the CTCR, and provides commuters, schoolchildren, tourists, and others with transportation for daily activities including commuting to work, accessing health care, and participating in educational activities. When the ferry is not in service, the next nearest Columbia River crossing is approximately 34 miles to the north on WA20/US395 and WA25/US395. This moderate effect would primarily fall on the CTCR.

**Recreation.** A less than one percent change in water-based recreation visitation due to effects on boat ramp accessibility at Lake Roosevelt could occur under MO1; thus, any impacts are expected to be negligible.

**Cultural resources.** Implementation of MO1 could negatively affect traditional cultural properties through increasing exposure and erosion of reservoir areas associated with increased reservoir level fluctuations.[15] Specifically, MO1 would increase the exposure of properties at Grand Coulee Dam (Lake Roosevelt) by 10 percent in terms of acre-days of exposure and would increase the frequency of reservoir elevation changes by approximately 32 percent. The resulting effects are expected to be major. Increases in exposure of Hayes Island (one of the main features at Kettle Falls), due to longer and more frequent drawdown periods, may lead to potential looting. This increased exposure may also allow some increased access for tribal religious practitioners, although such temporary access may not be perceived as beneficial. The effect on the Kettle Falls sacred site is expected to be minor relative to the No Action Alternative. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System cultural resource program.

**REGION C - DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS**

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region C under MO1 relative to the No Action Alternative, as follows:

**Fish.** MO1 would have mixed effects ranging from negligible beneficial (due to increased opportunity for non-powerhouse dam passage), to minor adverse effects to resident fish due to warmer summer water temperatures, reduced flows, or increased TDG and potential for gas bubble trauma in Region C. Effects to anadromous fish range from potential negligible beneficial increases to moderate increases depending on latent mortality assumptions. Some species are anticipated to have the potential for minor adverse effects, 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.

temperatures. Any minor adverse effects on resident and anadromous fish would have the potential to adversely impact fishing opportunities in Region C for Indian tribes, as well as low-income and minority subsistence fishers in the Region, while moderate increases in anadromous fish returns would have a beneficial impact.

MO1 mitigation includes the temporary extension of performance standard spill levels, in coordination with the Regional Forum.

**Power generation and transmission.** Under MO1 upward or downward rate pressure may result in a change in the average annual cost of electricity per household in Region C ranging from a decrease of 0.31 to an increase of 3.0 percent compared to the No Action Alternative, or up to approximately $27 per year compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.023 percent of household income compared to an increase of 0.011 percent for other households in Region C. As discussed in the No Action Alternative, energy burdens in Region C are already likely unaffordable for all households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal or both.

**Navigation and transportation** Effects on navigation and transportation are anticipated to be negligible in Region C under MO1 given that average annual cost increases represent less than 0.1 percent of total costs of navigation operations.

**Recreation.** A less than one percent change in water-based recreation visitation due to effects on boat ramp accessibility at Dworshak Reservoir may occur under MO1. A negligible to minor and adverse effect on the quality of water-based reservoir recreation is expected in Region C with the exception of the Clearwater River. In the Clearwater River, there is the potential for localized major adverse effects to recreational fishing along the Clearwater River in August and September due to increased turbidity from changes in outflows from Dworshak Dam. To the extent that low-income populations, minority populations or tribal populations in this region would have participated in the recreation activities or been employed in recreation-based jobs, impacts to environmental justice populations may occur. Information is not available regarding the makeup of recreational fishing participants along the Clearwater River; however, this is a very well-known site for steelhead fishing. While some of the businesses operating recreational fishing tours or some of the recreational participants may be low-income, minority or tribal; low-income populations, minority populations, and Indian tribes are not expected to comprise the majority of these affected visitors. As such, disproportionately high and adverse effects are not anticipated.

**Cultural resources**. Implementation of MO1 could adversely affect traditional cultural properties through increasing exposure and erosion associated with increased reservoir level fluctuations. Specifically, MO1 is expected to affect traditional cultural properties due to an increase in the number of high draft rate events at Dworshak Dam by over 100 percent as compared to the No Action Alternative resulting in major effects. However, some of the effects may prove to be beneficial as the increased high draft rate events could lead to increased access and visibility of properties. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

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

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region D under MO1 relative to the No Action Alternative, as follows:

**Fish**. MO1 would have mixed effects ranging from negligible beneficial (due to increased opportunity for non-powerhouse dam passage), to minor adverse effects to resident fish due to warmer summer water temperatures, changes in John Day pool elevation, reduced flows, or increased TDG and potential for gas bubble trauma in Region D. Effects to anadromous fish range from potential negligible beneficial increases to moderate increases depending upon latent mortality assumptions. Some species are anticipated to have the potential for minor adverse effects, particularly to sockeye salmon and fall Chinook salmon based on warmer summer water temperatures. Adverse effects on resident and anadromous fish would have the potential to adversely impact fishing opportunities in Region D for Indian tribes, as well as low-income and minority subsistence fishers in the Region, while moderate increases in anadromous fish returns would have a beneficial impact.

MO1 mitigation includes the temporary extension of performance standard spill levels, in coordination with the regional forum.

**Power generation and transmission.** Under MO1 the upward or downward rate pressure may result in a change in the average annual cost of electricity per household in Region D that would range from a decrease of 0.29 to an increase of 7.6 percent compared to the No Action Alternative, or up to approximately $64 per year compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.050 percent of household income compared to an increase of 0.037 percent for other households in Region D. As discussed in the No Action Alternative, energy burdens in Region D are already likely unaffordable for most households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Navigation and transportation.** Effects on navigation and transportation are anticipated to be negligible in Region D under MO1 given that average annual cost increases represent less than 0.1 percent of total costs of navigation operations.

**Recreation.** No changes in annual water-based recreation visitation associated with changes in boat ramp accessibility would occur under MO1. Minor effects to quality of fishing, hunting, wildlife viewing, swimming, and water sports associated with changing river and reservoir conditions may occur.

**Cultural Resources.** Effects on traditional cultural properties are anticipated to be consistent with the NAA in Region D under MO1.

**OTHER – AREAS OUTLIDE OF REGIONS A, B, C, AND D**

Because effects on resources would be primarily limited to Regions A, B, C, and D, effects on minority populations, low-income populations, or Indian tribes outside of Regions A, B, C, and D would not be anticipated relative to the No Action Alternative under MO1 other than for power generation and transmission.

**Power generation and transmission**. Under MO1, upward or downward rate pressure may result in a change in the average annual cost of electricity per household in other areas ranging from a decrease of 0.33 percent to an increase of 4.9 percent compared to the No Action Alternative, or up to approximately $42 per year compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.018 percent of household income compared to an increase of 0.014 percent for other households in this area. As discussed in the No Action Alternative, energy burdens in other areas are already likely unaffordable for most households with incomes below the Federal poverty level. Any downward rate pressure may be helpful for low-income households; however, energy burdens would likely remain unaffordable. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse.

**SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 1**

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.

#### *3.18.3.6 Multiple Objective Alternative 2*

Adverse effects related to the following resources may occur under MO2: fish, navigation and transportation, recreation and cultural resources. Effects to power and generation costs could vary between adverse and beneficial. The effects of MO2 on environmental justice populations resulting from changes in these resources are described below by region. Note, the co-lead agencies engage in ongoing actions to improve conditions for fish, which include, but are not limited to, habitat restoration, hatcheries, invasive species control, and predator management. In addition to the resources identified in Section 3.15.3.1, effects related to water supply on low-income, minority, and Indian tribes are anticipated to be negligible under MO2 because

MO2 does not have any measures that would affect the ability to deliver water to meet current water supply.

### REGION A – LIBBY, HUNGRY HORSE, AND ALBENI FALLS DAMS

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region A under MO2 relative to the No Action Alternative, as follows:

**Fish**. Resident fish species would experience minor to moderate, and in some locations major localized adverse effects from higher winter flows anticipated under MO2 downstream of Libby Dam on the Kootenai River in the late fall and downstream of Hungry Horse Dam in the winter. Resident fish species may also experience moderate adverse effects from reduced aquatic food production in Hungry Horse reservoir, increased varial zone effects to tributaries, and potential increased fish entrainment. In addition, reduced spring freshet would reduce sturgeon habitat on the Kootenai River. These effects have the potential to adversely affect fishing opportunities in Region A for Indian tribes, as well as low-income and minority subsistence fishers in the Region. MO2 mitigation includes:

- Plant 1- to 2-gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity. This would benefit ESA-listed Kootenai River White Sturgeon (KRWS) by providing a food source and complement ongoing habitat actions already being taken in the region.
- On the Hungry Horse Reservoir, install structural components like woody debris and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone to minimize effects of reservoir fluctuation where the tributaries enter the reservoir.
- On the Kootenai River, downstream of Libby, plant native wetland and riparian vegetation up to 100 acres along the river.
- Update and implement Invasive Plant Management Plan for the shoreline at Libby.

**Power generation and transmission.** Under MO2 upward or downward rate pressure may result in a change in the average annual cost of electricity per household in Region A ranging from a decrease of 0.61 percent to an increase of less than 0.01 percent, or up less than $1 per year compared to the No Action Alternative, depending on the county. This change represents 0.01 percent of median household income for households in Region A, a negligible portion of median household income for all households in Region A. As discussed in the No Action Alternative, energy burdens in Region A are already likely unaffordable for all households with incomes below the Federal poverty level. Any downward rate pressure may be helpful for low-income households; however, energy burdens would likely remain unaffordable in this region. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Recreation.** A less than one percent change in water-based recreation visitation due to effects on boat ramp accessibility at Hungry Horse Reservoir and Lake Koocanusa would occur under MO2. 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 related to changes in habitat conditions.

**Cultural resources.** Implementation of MO2 could adversely affect traditional cultural properties through increasing exposure and erosion associated with increased reservoir level fluctuations. At the Hungry Horse Project, the exposure of traditional cultural properties and amplitude of elevation changes would result in moderate effects. The Bear Paw Rock sacred site would experience no change relative to the NAA. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

### REGION B - GRAND COULEE AND CHIEF JOSEPH DAMS

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region B under MO2 relative to the No Action Alternative, as follows:

**Fish**. Increased entrainment risk for some resident species (bull trout, kokanee, rainbow trout, and burbot), increased burbot and kokanee egg desiccation, and tributary access issues for redband rainbow trout could cause minor to moderate adverse effects to fish in Lake Roosevelt in Region B under MO2. Upper Columbia River salmon and steelhead would experience a negligible adverse impact in Region B below Chief Joseph Dam. These effects have the potential to have a negligible to minor adverse effect to fishing opportunities for Indian tribes, as well as low-income and minority subsistence fishers in the Region.

MO2 mitigation includes developing additional spawning habitat at Lake Roosevelt to minimize impacts to non-listed resident fish.

**Power generation and transmission.** Under MO2 upward or downward rate pressure may result in a change in the average annual cost of electricity per household in Region B ranging from a decrease of 1.3 percent to an increase of 0.46 percent, or up to approximately $4.50 per year compared to the No Action Alternative, depending on the county. This change represents less than 0.01 percent of median household income for households in Region B. As discussed in the No Action Alternative, energy burdens in Region B are already likely unaffordable for most households with incomes below the Federal poverty level. Any downward rate pressure in Region B may reduce the number of low-income households where energy burdens are unaffordable. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both. Payments to the CTCR, which are based on Bonneville power sales revenue and generation at Grand Coulee Dam are expected to decrease by approximately 2%. The Spokane Tribe of Indians will also begin receiving payments based on Bonneville power sales revenue and generation at Grand Coulee Dam.

That payment is expected to begin in 2021 and under MO2 is expected to decrease by approximately 2%.

**Navigation and transportation.** Ferry operations on Lake Roosevelt could be affected under MO2 due to anticipated drawdowns in wet years. In wet years, the Inchelium-Gifford Ferry on Lake Roosevelt would not be able to operate for approximately 36 days in the year, which is 9 more days than anticipated under the No Action Alternative in wet years at this location. The Inchelium-Gifford Ferry is operated by the CTCR, and provides commuters, schoolchildren, tourists, and others with transportation for daily activities including commuting to work, accessing health care, and participating in educational activities. When the ferry is not in service, the next nearest Columbia River crossing is approximately 34 miles to the north on WA20/US395 and WA25/US395. This moderate effect would primarily fall on the CTCR.

**Recreation.** Effects on recreation are anticipated to be negligible in Region B under MO2.

**Cultural resources.** Implementation of MO2 could adversely affect traditional cultural properties through increasing exposure and erosion associated with increased reservoir level fluctuations.[16] Specifically, MO2 would increase the exposure of traditional cultural properties coupled with the increased frequency of elevation changes would cause moderate effects. Increases in exposure of Hayes Island (one of the main features at Kettle Falls), due to longer and more frequent drawdown periods, may lead to potential looting. This increased exposure may also allow some increased access for tribal religious practitioners, although such temporary access may not be perceived as beneficial. The effect on the Kettle Falls sacred site is expected to be minor relative to the No Action Alternative. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

### REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region C under MO2 relative to the No Action Alternative, as follows:

**Fish.** Under MO2, decreased abundance of Snake River spring Chinook salmon and Snake River steelhead predicted by the CSS model (LCM predicted a minor increase) would contribute to minor beneficial effects (LCM) to major adverse effects (CSS) on other fishing opportunities in Region C. Adverse effects to kokanee at Dworshak Reservoir are also anticipated. These modeled changes could range from minor benefits to a major adverse impact to Indian tribes in the region for whom salmon and steelhead are a predominant element of cultural traditions and traditional diet, as well as sources of revenue. Low-income and minority subsistence fishers in the Region could also be affected.

**Power generation and transmission**. Under MO2 downward rate pressure may result in a 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.

decrease of 0.82 to an increase of 0.20 percent, or up to approximately $2 per year compared to the No Action Alternative, depending on the county. This change represents less than 0.01 percent of median household income for households in Region C. As discussed in the No Action Alternative, energy burdens in Region C are already likely unaffordable for all households with incomes below the Federal poverty level. Any downward rate pressure may be helpful for low-income households; however, energy burdens would likely remain unaffordable in this region.

**Navigation and transportation.** Negligible effects would be anticipated for commercial navigation or commercial cruise lines in Region C under MO2. Average annual cost increases represent less than 0.1 percent of total costs of navigation operations. No effects to ferry operations are anticipated in Region C.

**Recreation.** A minor (6.5 percent) decrease in water-based recreation visitation due to effects on boat ramp accessibility at Dworshak Reservoir would occur under MO2. This would reduce visitation by approximately 12,000 annual visits. Some portion of the visits to Dworshak Reservoir may be attributable to low-income populations, minority populations, and Indian tribes (particularly Nez Perce Tribe) that reside in relative proximity to the affected recreation sites. 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.

**Cultural resources**. Implementation of MO2 could adversely affect traditional cultural properties through increasing exposure and erosion associated with increased reservoir level fluctuations. MO2 could result in moderate effects to TCPs at Dworshak Reservoir where TCPs are present in the drawdown zone by allowing for wider and more frequent range of shifts in reservoir elevations. Under MO2, effects to cultural resources near the lower Snake River projects are expected to be minor as compared to the No Action Alternative. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

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

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region D under MO2 relative to the No Action Alternative, as follows:

**Fish**. Resident fish effects in Region D from MO2 would be negligible. Under MO2, decreased abundance of Snake River spring Chinook salmon and Snake River steelhead, upper Columbia River spring Chinook salmon, and decreased in-river survival rates of upper Columbia River steelhead predicted by the CSS model would contribute to major adverse effects on other fishing opportunities in the Columbia River in Region D. Minor to moderate increases in Snake River Chinook abundance predicted by the LCM would have a minor beneficial effect. These modeled changes could represent a range of potential impacts to Indian tribes in the region, for whom salmon and steelhead are a predominant element of cultural traditions and traditional diet, as well as sources of revenue. Low-income and minority subsistence fishers in the Region could also be affected.

**Power generation and transmission**. Under MO2 upward or downward rate pressure may result in a change in the average annual cost of electricity per household in Region D would ranging from a decrease of 0.85 percent to an increase of 0.26 percent, or up to approximately $3 per year compared to the No Action Alternative, depending on the county. This represents a negligible portion of median household income for households in Region D. As discussed in the No Action Alternative, energy burdens in Region D are already likely unaffordable for most households with incomes below the Federal poverty level. Any downward rate pressure in Region D may reduce the number of low-income households where energy burdens are unaffordable. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Navigation and transportation.** Effects to navigation and transportation are anticipated to be negligible in this region given that average annual cost increases represent less than 0.1 percent of total costs of navigation operations.

**Recreation.** No changes in annual water-based recreation visitation associated with changes in boat ramp accessibility would occur under MO2. 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.

**Cultural resources.** Effects to cultural resources are anticipated to be minor at John Day and no change in relation to the NAA at McNary, The Dalles, or Bonneville. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

**OTHER – AREAS OUTLIDE OF REGIONS A, B, C, AND D**

Because effects on resources would be primarily limited to Regions A, B, C, and D, effects on minority populations, low-income populations, or Indian tribes outside of Regions A, B, C, and D would not be anticipated relative to the No Action Alternative under MO2 other than for power generation and transmission.

**Power generation and transmission**. Under MO2 upward or downward rate pressure may result in a change in the average annual cost of electricity per household in other areas ranging from a decrease of 0.86 percent to an increase of 0.10 percent, or up to approximately $1 per year compared to the No Action Alternative, depending on the county. This represents a negligible portion of median household income for households in these areas. As discussed in the No Action Alternative, energy burdens in other areas are already likely unaffordable for most households with incomes below the Federal poverty level. Any downward rate pressure in this region may reduce the number of low-income households where energy burdens are unaffordable. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 2**

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.

### *3.18.3.7 Multiple Objective Alternative 3*

Adverse effects related to the following resources are expected under MO3: fish, power generation and transmission, navigation and transportation, water supply, recreation and cultural resources. The effects of MO3 on environmental justice populations resulting from changes in these resources are described below by region. Note, the co-lead agencies engage in ongoing actions to improve conditions for fish, which include, but are not limited to, habitat restoration, hatcheries, invasive species control, and predator management. As discussed in Section 3.7, *Power Generation and Transmission*, Indian tribes could also be affected by changes in the Bonneville F&W Program funding under MO3, which would decrease by approximately $32 million at least. Given that the lower Snake River dams would no longer be in place to operate, Bonneville's funding for the effects of construction and operation of these dams through the lower Snake River Compensation Plan programs would cease.

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

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region A under MO3 relative to the No Action Alternative, as follows:

**Fish.** Similar to MO1, there could be minor to moderate adverse effects to food webs, varial zones at the mouth of tributaries that are important for migration, and habitat for bull trout, Kootenai River White Sturgeon, and other native fish in Region A. Effects on resident fish have the potential to adversely impact fishing opportunities in Region A for Indian tribes, as well as low-income and minority subsistence fishers in the Region.

MO3 mitigation includes:

- Plant 1- to 2-gallon cottonwoods near Bonners Ferry to improve habitat and floodplain connectivity. This would benefit ESA-listed Kootenai River White Sturgeon (KRWS) by providing a food source and complement ongoing habitat actions already being taken in the region.
- On the Hungry Horse Reservoir, install structural components like woody debris and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone to minimize effects of reservoir fluctuation where the tributaries enter the reservoir.
- On the Kootenai River, downstream of Libby, plant native wetland and riparian vegetation up to 100 acres along the river.
- Update and implement Invasive Plant Management Plan for the shoreline at Libby.

**Power generation and transmission**. Under MO3 upward rate pressure may result in an increase in the average annual cost of electricity per household in Region A of 0.21 to 7.2 percent compared to the No Action Alternative, or up to approximately $71 per year compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.17 percent of household income compared to an increase of 0.11 percent for other households in Region A. As discussed for the No Action Alternative, energy burdens in Region A are already likely unaffordable for the all households with incomes below the poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Recreation.** A less than one percent change in annual water-based recreation visitation due to effects on boat ramp accessibility at Hungry Horse Reservoir and Lake Koocanusa would occur under MO3.

**Cultural resources** In Region A, implementation of MO3 would result in no change to traditional cultural properties relative to the NAA. The Bear Paw Rock sacred site would experience no change relative to the NAA.

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

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region B under MO3 relative to the No Action Alternative, as follows:

**Fish.** Predicted effects range from negligible decreases in steelhead in-river migration survival to variable increases in the abundance of anadromous species such as spring Chinook below Chief Joseph Dam are anticipated due to higher spill under MO3 depending on latent mortality assumptions. These modeled effects are mixed but improved conditions could increase opportunities for fishing for these species over the long term in Region B below Chief Joseph Dam. Effects to resident fish would range from minor adverse effects from increased wintertime entrainment to minor beneficial effects due to reduced risk of kokanee and burbot egg stranding. Many of the relationships considered for resident fish would have no effect compared to the No Action Alternative. As such, adverse effects to low-income or minority populations or Indian tribes are not anticipated.

MO3 mitigation includes developing additional spawning habitat at Lake Roosevelt to minimize impacts to non-listed resident fish.

**Power generation and transmission**. Under MO3 upward rate pressure may result in an increase in the average annual cost of electricity per household in Region B of 0.21 to 11.3 percent, or up to approximately $110 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.10 percent of household income compared to an increase of 0.056 percent for other households in Region B. As discussed for the No Action

Alternative, energy burdens in Region B are already likely unaffordable for most households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both. Payments to the CTCR, which are based on Bonneville power sales revenue and generation at Grand Coulee Dam are expected to increase by approximately 2% to 5%. The Spokane Tribe of Indians will also begin receiving payments based on Bonneville power sales revenue and generation at Grand Coulee Dam. That payment is expected to begin in 2021 and under MO3 is expected to increase by approximately 2% to 5%.

**Navigation and transportation.** Ferry operations on Lake Roosevelt could be affected under MO3 due to anticipated drawdowns in wet years. In wet years, the Inchelium-Gifford Ferry on Lake Roosevelt would not be able to operate for approximately 29 days of the year in total, which is 2 additional days than anticipated under the No Action Alternative in wet years at this location. This moderate effect would primarily fall on the CTCR community.

**Recreation.** No changes in annual water-based recreation visitation associated with changes in boat ramp accessibility would occur under MO3.

**Cultural resources.** Effects on traditional cultural properties represent no change relative to the NAA in Region B under MO3. Kettle Falls sacred site would experience no change relative to the No Action Alternative.

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

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region C under MO3 relative to the No Action Alternative, as follows:

**Fish**. When dams are breached under MO3, reservoir conditions on the Snake River would transition from reservoirs to a riverine system. Short-term adverse effects are anticipated for most fish species. Some resident fish, such as white sturgeon and bull trout, may benefit under this alternative. In addition, long-term increases in the abundance of anadromous species due to dam breach are anticipated to occur, particularly Snake River runs of Chinook salmon and steelhead. There would be increased spawning habitat for fall Chinook salmon. All species of salmon and steelhead are culturally important to Indian tribes and increased salmon and steelhead returns could result in a major beneficial change. Long-term adverse effects are anticipated for some non-native resident fish species that prefer reservoir conditions, such as walleye. Effects on resident fish have the potential to adversely impact fishing opportunities for Indian tribes, as well as low-income and minority subsistence fishers in this region.

MO3 mitigation includes:

- Construct a trap-and-haul facility at McNary and conduct at least two years of trap-and-haul operations for Snake River fish (Chinook salmon, Sockeye, Steelhead) to allow removal and transport of these fish from the lower Snake River prior to breaching.
- Raise additional hatchery fish to help to address two lost year classes of anadromous fish, prior to the initiation of each phase of breaching (2 phases) of the lower Snake River dams.
- Modify the Tucannon River channel at the delta to allow Bull Trout, salmon, and steelhead passage after lower Snake River water elevations decrease from breaching.
- On the Snake River, prior to dam breaching, trap-and-haul white sturgeon from impacted areas to locations in Hells Canyon and downstream of McNary Dam on the Columbia River.
- Develop and implement a planting plan for approximately 1500 acres of wetland and riparian species along the exposed shorelines.
- Develop and implement a restoration plan for approximately 155 acres of wetlands downstream of Ice Harbor.

**Power generation and transmission**. Under MO3 upward rate pressure may result in an increase in the average annual cost of electricity per household in Region C of 0.34 to 6.8 percent, or up to approximately $61 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.067 percent of household income compared to an increase of 0.035 percent for other households in Region C. As discussed in the No Action Alternative, energy burdens in Region C are already likely unaffordable for all households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Navigation and transportation.** With dam breach, the navigation channel in the Snake River would not be maintained, eliminating commercial navigation access up the Snake River resulting in major effect. This would increase costs to shippers across Regions C and D as discussed in Section 3.10, Transportation and Navigation. These increases would result in regional economic effects of changes in navigation mode from river to rail and truck, as well as likely lead to some displacement of workers. Due to the distributed nature of the navigation industry, while some laborers are likely to be low-income, minority, or members of tribal communities, these effects do not appear likely to be concentrated in one group or geographic area. In addition, wheat producers are the primary shippers of commodities on the shallow-draft Snake River. Based on information from the 2017 Census of Agriculture, minorities likely make up a very small percentage of wheat producers in Region C; for example, less than three percent of all farm producers in Region C are Hispanic (NASS 2017). Based on unemployment claims for Washington State, the number of minority farmworkers in Region C is very small (less than 0.1 percent Hispanic) (WAESD 2019). Additional analysis of impacts to affected communities is included in Section 3.10.3.5.

**Water supply:**

- **Municipal and industrial use.** Under MO3, pumps and wells that supply municipal and industrial uses in the Lewiston area would no longer be operational once the dams were breached. Implementation of MO3 could affect access to diversions in the Lewiston area and other small municipal and industrial uses along the river; approximately 21,330 acre-feet is diverted for municipal and industrial (M&I) purposes. A total of 16 points of diversion from surface water, which may use up to 9,230 acre-feet per year, and approximately 63 groundwater wells, which may use up to 12,100 acre-feet could be affected. These diversions would need to be modified to continue operation after dam breaching. The water supply analysis models these costs as a decrease in household income which has a negative impact on the regional economy in terms of jobs, labor income, and output (sales). These effects were estimated as a loss of 55 jobs, $2.3 million of labor income, and $7.5 million of output (sales). Because the effects are minor (less than 0.5 percent of jobs and labor income in the region), the effects related to a loss of municipal and industrial water supply are not expected to result in disproportionately high and adverse effects on minority populations, low-income populations, or Indian tribes.

- **Irrigated farmland.** Under MO3, pumps that supply irrigation in Region C would no longer be operational once the dams are breached and groundwater elevations could be substantially impacted. The water supply analysis assumes all 47,840 irrigated acres receiving water from the current pumps in Region C would no longer be irrigated because pumps and wells that supply this water would no longer be operational. This decreased agricultural production is assumed to result in the loss of all employment, labor income, and output (sales) associated with production of these acres. Compared to the No Action Alternative, 4,822 jobs are expected to be lost, with a decrease in labor income and output equal to what was estimated under the No Action Alternative (i.e., approximately $232 million in labor income and output of $461 million). These jobs are the result of gross farm income generated from crop production on approximately 47,840 acres of farmland. However, based on unemployment claims for Washington State, the number of minority farmworkers in counties in the Ice Harbor and Lower Monumental water supply socioeconomic region is very small (for example, less than 0.1 percent is Hispanic) (WAESD 2019). Given the location of various low-income census block groups within the Ice Harbor and Lower Monumental area, low-income populations may be affected by these changes to employment and labor income. Because the effects are relatively small, the effects on low-income populations, minority populations and Indian tribes related to a loss in irrigation are not expected to result in disproportionately high and adverse effects on minority populations, low-income populations, or Indian tribes.

**Recreation.** Due to dam breaching and construction activities, there would be major 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 in the short term. Some land-based visitation would return as access to lower Snake River areas is reopened. The reduction of only water-based reservoir recreation compared to No Action Alternative at the lower Snake river would result in a decrease of 0.9 million visitors. In the short-term, non-local visitor expenditures could decrease by approximately $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 could be re-opened to some of the recreation areas. A reduction in only the reservoir water-based visitors compared to No Action Alternative could 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. 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 the No Action Alternative.

In addition to potential changes in regional spending, changes in other social effects could be major and adverse, particularly in the short term, as communities that are economically dependent on visitation to the Lower Snake River projects and Lake Wallula could be adversely affected. However, during the transition period, to the extent that low-income populations, minority populations or tribal populations in this region would have participated in the recreation activities or been employed in recreation-based jobs, impacts to environmental justice populations may occur. While some recreational participants may be part of low-income populations, minority populations, and Indian tribes, these populations are not expected to comprise the majority of these affected visitors. As such, disproportionately high and adverse effects are not anticipated.

**Cultural resources.** Following dam breach, the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite projects would experience moderate effects to traditional cultural properties associated with sediment erosion and deposition. The projects could also experience increased effects under MO3 associated with public access including looting, vandalism, creation of trails, and unauthorized activities. At the same time, the return of this portion of the Snake River to riverine conditions would allow practitioners of traditional lifeways the chance to return to locations that have been inaccessible for decades. Because of the unique ties between the landscape and traditional Native American lifeways, this benefit would be most recognized in tribal communities. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

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

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region D under MO3 relative to the No Action Alternative, as follows:

**Fish**. Short-term increased sedimentation above McNary Dam could have a minor, temporary adverse effect on fishing conditions. Long-term increases in the abundance of anadromous recreational fishing species, including Chinook salmon and other salmonids as well as white sturgeon, are anticipated to occur due to dam breach under MO3. All species of salmon and steelhead are culturally important to Indian tribes and increased salmon and steelhead returns could represent a substantial beneficial change.

MO3 mitigation includes:

- Temporary extension of performance standard spill levels in coordination with the Regional Forum.
- If conditions in the tailrace are impeding upstream passage of adult salmon and steelhead or actionable TDG impacts to fish are observed through real-time monitoring, the co-lead agencies would implement performance standard spill operations until the situation is remedied.

**Power generation and transmission**. Under MO3, upward rate pressure may result in an increase in the average annual cost of electricity per household in Region D of 0.70 to 15 percent, or up to approximately $130 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.14 percent of household income compared to an increase of 0.10 percent for other households in Region D. As discussed in the No Action Alternative, energy burdens in Region D are already likely unaffordable for most households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Navigation and transportation.** With dam breach, the navigation channel in the Snake River would be inaccessible for commercial navigation. This would increase costs to shippers across Regions C and D as discussed in Section 3.10, Transportation and Navigation. These increases would result in regional economic effects of changes in navigation mode from river to rail and truck, as well as likely lead to some displacement of workers. While some laborers are likely to be low-income, minority, or members of tribal communities, these effects do not appear likely to impact a specific environmental justice population or area.

**Water supply: irrigated farmland.** As described in Section 3.12, *Water Supply*, some areas of Region D may be affected by increased sediment deposition in water supplies following dam breach. Large pumps should not be affected, but smaller private pumps may be impacted by fine-grained material and require more frequent maintenance. However, these would likely not impact low-income populations, minority populations or Indian tribes. Tribal farming operations on the Umatilla Indian Reservation would not be expected to be affected, as their source for irrigation is the Columbia River, which would not be affected under this alternative (Reclamation 2019).

**Recreation.** Due to breach of Lower Snake River dams, sedimentation impacts along the south and east banks in Lake Wallula (behind McNary Dam) below the mouth of the Snake River would reduce annual water-based visitation by 5.6 percent under MO3. This would reduce visitation by approximately 163,000 annual visits. Sedimentation impacts would likely last for two to seven years. Overall regional economic effects would be minor. Some recreation visitation could be replaced or improved based on adaptation over time, as anadromous fish populations improve; this could include additional river-based recreation visits. However, during the transition period, to the extent that low-income populations, minority populations or tribal populations in this region would have participated in the recreation activities or would have been employed in recreation-based jobs, impacts to environmental justice populations may occur. While some recreational participants may be part of low-income populations, minority populations, and Indian tribes, these populations are not expected to comprise the majority of these affected visitors. As such, disproportionately high and adverse effects are not anticipated.

**Cultural resources**. Effects to traditional cultural properties are anticipated to be moderate at John Day as a result of the full pool operational measure. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

**OTHER – AREAS OUTLIDE OF REGIONS A, B, C, AND D**

Effects to minority populations, low-income populations, or Indian tribes may occur in the other areas under MO3 relative to the No Action Alternative, as follows:

**Power generation and transmission**. Under MO3, upward rate pressure may result in an increase in the average annual cost of electricity per household in other areas of 0.062 to 10.4 percent, or up to approximately $90 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian Tribes within the study area, this would represent an increase of approximately 0.083 percent of household income compared to an increase of 0.060 percent for other households in this area. As discussed in the No Action Alternative, energy burdens in other areas are already likely unaffordable for most households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 3**

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.

As discussed in Section 3.7, *Power Generation and Transmission*, Indian tribes could also be affected by changes in the F&W Program funding under MO3, which would decrease by approximately $32 million at least. Given that the lower Snake River dams would no longer be in place to operate, Bonneville's funding for the effects of construction and operation of these dams through the Lower Snake River Compensation Plan programs would cease.

#### *3.18.3.8 Multiple Objective Alternative 4*

Adverse effects related to the following resources are expected under MO4: fish, power generation and transmission, navigation and transportation, water supply, recreation and cultural resources. The effects of MO4 on minority populations, low-income populations, or Indian tribes resulting from changes in these resources are described below by region. Note, the co-lead agencies engage in ongoing actions to improve conditions for fish, which include, but are not limited to, habitat restoration, hatcheries, invasive species control, and predator management.

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

Adverse effects to minority populations, low-income populations, or Indian tribes may occur in Region A under MO4 relative to the No Action Alternative, as follows:

**Fish**. MO4 would have moderate to major adverse effects to bull trout, westslope cutthroat trout, and Kootenai River White Sturgeon due to lower reservoir levels in the summer. This could increase entrainment risk, varial zone effects, and reduce habitat and food availability in Region A as compared to the No Action Alternative. These effects would increase in dry years. Indian tribes value these fish for cultural and subsistence uses, and therefore, MO4 has the potential to have adverse effects on Indian tribes in Region A. Low-income and minority subsistence fishers in the Region could also be affected.

Mitigation under MO4 includes:

- Implement and expend the existing Invasive Aquatic Plant Removal program at Albeni Falls.
- On the Hungry Horse Reservoir, install structural components like woody debris, and plant vegetation at the tributaries (Sullivan and Wheeler Creeks, possibly more) to stabilize the channels, increase cover for migrating fish, and improve the varial zone to minimize impacts of reservoir fluctuation where the tributaries enter the reservoir.

**Power generation and transmission**. Under MO4 upward rate pressure may result in an increase in the average annual cost of electricity per household in Region A of 0.041 to 9.1 percent, or up to approximately $96 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.12 percent of household income compared to an increase of 0.089 percent for other households in Region A. As discussed for the No Action Alternative, energy burdens in Region A are already likely unaffordable for most households with incomes below the Federal poverty level. Any downward rate pressure may be helpful for low-income households; however, energy burdens would likely remain unaffordable. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Recreation.** A negligible (less than 1 percent change) in annual water-based recreation visitation due to effects on boat ramp accessibility at Hungry Horse Reservoir and Lake Koocanusa would occur under MO4. However, effects to water levels affecting local public and private docks at Lake Pend Oreille in low water years could have a major adverse effect on tourism and regional spending. Changes would be similar under low- and high-water-level years under MO4 relative to the No Action Alternative. Minor adverse effects on the quality of water-based recreation are expected under MO4. While some recreational participants may be part of low-income populations, minority populations, and Indian tribes, these populations are not expected to comprise the majority of these affected visitors. As such, disproportionately high and adverse effects are not anticipated.

**Cultural resources.** Major effects to traditional cultural properties would be expected at Hungry Horse as a result of much greater frequency of exposure and increases in frequency of elevation changes relative to the NAA. The Bear Paw Rock sacred site would experience greater effects under MO4 relative to the NAA. In drier than normal years, the summer reservoir elevation for Albeni Falls Dam would be lower than for the No Action Alternative. Bear Paw Rock would be subject to greater exposure and effects associated with modifications in access. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

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

Effects to minority populations, low-income populations, or Indian tribes may occur in Region B under MO4 relative to the No Action Alternative, as follows:

**Fish**. Resident fish in Region B would experience moderate to major effects in Lake Roosevelt. This is due to lower retention times resulting in higher entrainment rates and reduced productivity, as well as increased stranding of kokanee and burbot eggs, and increased varial zone effects such as tributary access impediments and increased predation risk. In dry years these effects would be more prominent and there could be adverse water quality effects to net pen fish and increased invasion of northern pike downstream. Below Chief Joseph Dam, negligible long-term improvements in Chinook salmon and steelhead are anticipated based on improved PITPH, as predicted in the LCM model. Any reductions in latent mortality would increase adult returns predicted by the LCM (there are no CSS model results available in Region B but increased adult returns associated with reductions in latent mortality would be consistent with CSS results from other regions). Under MO4, potential effects to fishing opportunities for Indian tribes, range from moderate adverse to moderate beneficial in Region B. Low-income and minority subsistence fishers in the Region could also be similarly affected.

The river mechanics analysis indicates minor increases in the mobility of bed material in Lake Roosevelt under MO4. If contaminated slag is present in the mobilized bed material, this could create additional toxicity in fish and other aquatic organisms. However, the change in potential toxicity is unknown. Reservoir drawdowns of longer duration under MO4 increase the exposure of shorelines. Increased exposure has the potential to increase mercury methylation rates, which could lead to greater buildup of mercury quantities in aquatic organisms (i.e. bioaccumulation) (Willacker 2016). Populations who rely on subsistence fishing in Lake Roosevelt could be adversely impacted if the bioaccumulation of heavy metals increases.

Mitigation under MO4 includes developing additional spawning habitat at Lake Roosevelt to minimize impacts to resident fish.

**Power generation and transmission**. Under MO4 upward rate pressure may result in an increase in the average annual cost of electricity per household in Region B of 0.25 to 14 percent, or up to approximately $140 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.12 percent of household income compared to an increase of 0.066 percent for other households in Region B. As discussed in the No Action Alternative, energy burdens in Region B are already likely unaffordable for most households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both. Payments to the CTCR, which are based on Bonneville power sales revenue and generation at Grand Coulee Dam are expected to increase by approximately 5% to 9%. Spokane Tribe of Indians will also begin receiving payments based on Bonneville power sales revenue and generation at Grand Coulee Dam. That payment is expected to begin in 2021 and under MO4 is expected to increase by approximately 5% to 9%.

**Navigation and transportation.** Ferry operations on Lake Roosevelt could be affected under MO4 due to anticipated drawdowns in wet years. In wet years, the Inchelium-Gifford Ferry on Lake Roosevelt would not be able to operate for approximately 36 days of the year, which is 9 additional days than anticipated under the No Action Alternative in wet years at this location. The Inchelium-Gifford Ferry is operated by the CTCR, and provides commuters, schoolchildren, tourists, and others with transportation for daily activities including commuting to work, accessing health care, and participating in educational activities. When the ferry is not in service, the next nearest Columbia River crossing is approximately 34 miles to the north on WA20/US395 and WA25/US395. This moderate effect would primarily fall on the CTCR community.

**Recreation.** A reduction in annual water-based recreation visitation due to effects on boat ramp accessibility at Lake Roosevelt would occur under MO4. Visitation would decrease by approximately 45,000 visitor days (6 percent) in high-water-level years and decrease by approximately 175,000 visitor days (24 percent) in low-water-level years, a major adverse effect in this region. Changes in the quality of recreational experience are expected to be both adverse and beneficial. Some portion of the visits to Lake Roosevelt may be attributable to the low-income populations, minority populations, and Indian tribes (particularly the Spokane Tribe and the Confederated Tribe of the Colville Reservation, whose lands border Lake Roosevelt) could experience adverse effects from change in water-based recreation visitation. While specific visitation by tribal community members in visitation at Lake Roosevelt is not known, their participation would be captured in local visitation estimates to the lake. According to the National Park Service, approximately 30 percent of trips to Lake Roosevelt represent local day use trips (those visiting from less than 60 miles away) (Cullinane Thomas 2018). This would equate to approximately 13,500 visits a year (averaging 36 visits per day) for all local visitors that may be affected under MO4. In addition to these visits, some portion of the additional non-local visits (70 percent of visits) are likely to be individuals that are part of low-income populations, minority populations, and Indian tribes. Overall, environmental justice populations are not expected to comprise the majority or a substantial portion of affected visitors. As such, these populations are not expected to experience disproportionately high and adverse effects related to recreation.

**Cultural resources.** Implementation of MO4 could adversely affect traditional cultural properties through increasing exposure and erosion associated with increased reservoir level fluctuations.[17] Specifically, MO4 would increase exposure at the Grand Coulee Project and would increase the frequency and the amplitude of elevation changes, resulting in major effects to TCPs relative to the NAA at Grand Coulee. Increases in exposure of Hayes Island (one of the main features at Kettle Falls), due to longer and more frequent drawdown periods, may lead to potential looting. This increased exposure may also allow some increased access for tribal religious practitioners, although such temporary access may not be perceived as beneficial. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

#### REGION C – DWORSHAK, LOWER GRANITE, LITTLE GOOSE, LOWER MONUMENTAL, AND ICE HARBOR DAMS

Effects to minority populations, low-income populations, or Indian tribes may occur in Region C under MO4 relative to the No Action Alternative, as follows:

**Fish**. Under MO4, a wide range of predicted changes to adult salmon and steelhead abundance vary by model and range from major decreases (LCM without latent mortality effects) to major increases (CSS). These effects (either adverse or beneficial) would be noticeable to fishers. All species of salmon and steelhead are culturally important to Indian tribes and 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.

while major adverse impacts to adult abundance would result in the opposite effect. There may also be increased gas bubble trauma for bull trout and other resident fish in Region C. Adverse effects to resident fish have the potential to impact fishing opportunities in Region C. Low-income and minority subsistence fishers in the Region could also be affected by changes in fishing opportunities.

Mitigation under MO4 includes:

- Temporary extension of performance standard spill levels in coordination with the Regional Forum.
- Modify the Little Goose Raceway infrastructure to de-gas the water in the raceway during collection for transport. This would allow the fish to be transported in water with lower TDG than that in the river.

**Power generation and transmission**. Under MO4 upward rate pressure may result in an increase in the average annual cost of electricity per household in Region C of 0.19 to 8.8 percent, or up to approximately $79 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.084 percent of household income compared to an increase of 0.044 percent for other households in Region C. As discussed in the No Action Alternative, energy burdens in Region C are already likely unaffordable for all households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Navigation and transportation.** Effects on navigation and transportation, are anticipated to be negligible in Region C under MO4, given that only average annual costs for commercial navigation are anticipated to slight decrease.

**Water supply**. No changes from the No Action Alternative are anticipated in Region C under MO4.

**Recreation**. No changes in annual water-based recreation visitation associated with changes in boat ramp accessibility would occur under MO4.

**Cultural resources.** Effects to traditional cultural properties are anticipated to be minor at Lower Granite, Little Goose, Lower Monumental, and Ice Harbor. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

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

Effects to minority populations, low-income populations, or Indian tribes may occur in Region D under MO4 relative to the No Action Alternative, as follows:

**Fish**. Under MO4, a wide range of predicted changes to adult salmon and steelhead abundance vary by model and range from moderate decreases (LCM) to substantial increases (CSS). These effects (either adverse or beneficial) would be noticeable to fishers. All species of salmon and steelhead are culturally important to Indian tribes and increased salmon and steelhead returns could represent a major beneficial change, while major adverse effects to adult returns would result in the opposite effect. Increased TDG and lower Columbia River drawdowns could reduce fish habitat availability for resident fish. Adverse effects on resident fish have the potential to affect fishing opportunities in Region D. Low-income and minority subsistence fishers in the Region could also be affected by changes in fishing opportunities.

Mitigation under MO4 includes the temporary extension of performance standard spill levels in coordination with the Regional Forum.

**Power generation and transmission**. Under MO4 upward rate pressure may result in an increase in the average annual cost of electricity per household in Region D of 0.35 to 18 percent, or up to approximately $160 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.17 percent of household income compared to an increase of 0.12 percent for other households in Region D. As discussed in the No Action Alternative, energy burdens in Region D are already likely unaffordable for most households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**Navigation and transportation.** As discussed in Section 3.10, Transportation and Navigation, effects on navigation and transportation are anticipated to be negligible in Region D under MO4 given that average annual cost increases would representing less than 0.1 percent of total costs of navigation operations.

**Water supply: Irrigated farmland.** Changes in pumping efficiencies related to drawdowns of the John Day Reservoir in Region D would result in increased pumping costs to meet irrigation needs; these additional total annual energy costs are estimated to range from $260,000 to $277,000. This increased spending is expected to result in an average annual decrease in employment (fewer than five jobs) and labor income ($55,000 to $59,000) and output ($176,000 to $188,000). These effects represent less than 0.01 percent of jobs and labor income in the John Day water supply region.

**Recreation**. No changes in annual water-based recreation visitation associated with changes in boat ramp accessibility would occur under MO4.

**Cultural resources.** Implementation of MO4 could adversely affect traditional cultural properties through increasing exposure and erosion associated with increased reservoir level fluctuations. However, these effects are expected to be minor relative to the NAA at the four projects in this region. Effects to cultural resources would be mitigated through the ongoing Federal Columbia River Power System program.

**OTHER – AREAS OUTSIDE OF REGIONS A, B, C, AND D**

Because effects on resources would be primarily limited to Regions A, B, C, and D, effects on minority populations, low-income populations, or Indian tribes outside of Regions A, B, C, and D would not be anticipated relative to the No Action Alternative under MO4 other than for power generation and transmission.

**Power generation and transmission**. Under MO4, upward rate pressure may result in an increase in the average annual cost of electricity per household in other areas of 0.062 to 11 percent, or up to approximately $110 per year, compared to the No Action Alternative, depending on the county and the replacement portfolio. For census block groups in low-income populations, minority populations, or Indian tribes within the study area, this would represent an increase of approximately 0.072 percent of household income compared to an increase of 0.055 percent for other households in this area. As discussed for the No Action Alternative, energy burdens in other areas are already likely unaffordable for most households with incomes below the Federal poverty level. Any upward rate pressure could impact low-income households, but these impacts would occur across the region at levels that would not be considered disproportionately high and adverse. In some cases, these low-income households are also minority, tribal, or both.

**SUMMARY OF EFFECTS – MULTIPLE OBJECTIVE ALTERNATIVE 4**

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.

## 3.19 IMPLEMENTATION AND SYSTEM COST ANALYSIS

The purpose of the cost analysis is to provide an estimate of the total cost for implementing, operating and maintaining the system under each of the MOs. The emphasis of the cost analysis is to understand the cost differences among the alternatives, particularly between the proposed MOs and the No Action Alternative. Implementation costs include the costs of constructing proposed structural measures under the MOs. All alternatives including the NAA have costs associated with operating and maintaining the Columbia River System, costs that may change relative to the structural and/or operational measures included under an MO. These on-going future costs include capital investments, routine and non-routine operations costs (including extraordinary maintenance (NREX)), and mitigation costs including fish and wildlife programs costs. For the purpose of the cost analysis, these future costs are referred to as “system costs.”

The cost analysis is focused on 14 Federal multiple purpose dams (projects), reservoirs, and navigation channels known as the Columbia River System (CRS).

The cost analysis presents annual equivalent costs over the 50-year period of analysis in 2019 dollars.[1] For consistency across alternatives, construction of the structural measures is assumed to begin in 2021 and occur over a 2-year period. However, given the uncertainty around the potential implementation timing for a complex alternative such as the dam breaching alternative (MO3), a sensitivity analysis was completed to determine the effect of construction timing on costs (described further below and in Appendix Q, *Cost Analysis*). Additionally, it should be noted that there are multiple areas of uncertainty related to the cost analysis in general. These include factors such as utilizing preliminary or planning level designs for structural measures; assessing capital costs and operations and maintenance (O&M) cost estimates based on these designs; as well as the uncertainty related to implementation or construction timing that would affect cost estimates.

The following section provides a summary of the cost analysis methodology, followed by a section summarizing cost analysis results. Additional details regarding the multi-step process employed to complete the cost analysis, including the data collected, cost engineering details and related information is presented in Appendix Q, *Cost Analysis*. The appendix also provides detailed cost results for each action alternatives as well as the methods and results of a regional economic impact evaluation (Annex C of Appendix Q). The regional economic impact analysis estimates the jobs and income associated with implementation and system costs under the No 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).

### 3.19.1 Summary of Cost Analysis Methodology

The No Action Alternative provides a baseline for understanding the costs associated with operating and maintaining the CRS under its current configuration and operation regime. The No Action Alternative also provided a starting point for identifying how costs would change as various structural or operational changes or both are made under MOs. The No Action Alternative was developed with extensive input from experts across the three co-lead agencies (Bonneville, Reclamation, and the Corps). A comprehensive accounting of all costs required to operate and maintain the CRS was developed based upon historic, current and anticipated future expenditures. The cost categorizes shown in Table 3-307 account for all implementation and system costs. The costs are broadly grouped by construction of structural measures (implementation costs), capital and O&M costs, and mitigation costs.

Under the No Action Alternative it was assumed the CRS would continue to be operated in a manner similar to current operations, balancing operations for congressionally authorized purposes across the CRS. Under the No Action Alternative, co-lead agencies will continue to make large capital investments in power-related improvements, additions, and replacements, as needed, to meet reliability standards, efficiency needs, environmental requirements, safety and security standards, and other requirements. In addition, non-routine and routine O&M costs would continue to meet system requirements; these include non-routine extraordinary maintenance (NREX) costs (both power and joint), and non-routine navigation costs, while routine O&M costs would occur for hydropower, cultural resources, navigation, recreation, fish and wildlife, and other routine costs.

Current operations include mitigation activities, actions agreed to in previous ESA consultations among the co-lead agencies, NMFS, and USFWS. The Bonneville F&W Program funds hundreds of projects each year to mitigate the impacts of the development and operation of the Federal hydropower system. In addition, the Corps and the Reclamation provide funding for fish and wildlife mitigation measures and activities under obligations including the ESA. The Corps uses CRFM appropriations to fund mitigation for fish and wildlife construction activities, while Reclamation funds habitat improvement, hatcheries and monitoring activities. Bonneville funds, either directly to the Corps and Reclamation or as a reimbursement to the U.S. Treasury, for the power share of mitigation activities, such as hatchery operations, fish stocking, elk habitat maintenance, and others.

After the No Action Alternative costs were established, the costs for each for the structural measures included in the MOs were developed by the cost engineers at the Corps Mandatory Cost Center of Expertise at the Walla Walla District. Next, an extensive evaluation was conducted on how the structural and operational measures under each of the MOs would affect the capital costs and routine and non-routine operations and maintenance costs compared to the No Action Alternative. Once these changes were estimated, they were reviewed by operations and/or project staff to ensure estimates were consistent with their knowledge of system operations and related costs.

**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 |

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.

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 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 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.

Additional mitigation measures were also developed under the MOs that would mitigate adverse impacts (for additional detail, please refer to Chapter 5 of the EIS and Annex B of the Cost Analysis appendix). The measures were identified after the resource evaluations and include reasonably foreseeable activities that could be undertaken to avoid, minimize, or mitigate adverse impacts from occurring under the MOs. These activities may include protecting cultural resources, improving or mitigating fish and wildlife or water quality impacts under the breach scenario, among others. The costs for these additional mitigation measures were estimated by the cost engineers at the Mandatory Cost Center for Expertise with input from Corps, Reclamation, and Bonneville specialists.[3]

### 3.19.2 Summary of Columbia River System Operations Implementation and System Costs

A summary of the estimated costs and cost differences among the MOs is provided in this section. A detailed presentation of costs by project and cost category is provided in Appendix Q, *Cost Analysis*.

As shown in Table 3-308, the estimated total cost for operating and maintaining the CRS under the No Action Alternative is approximately $1.06 billion annually. As described in the previous section, the No Action Alternative costs include capital, O&M and mitigation costs. Mitigation costs include the Bonneville F&W Program; Bonneville's funding of the LSRCP; the Corps Columbia River Fish Mitigation (CRFM) costs; Reclamation ESA-related costs; as well as additional measures to mitigate adverse effects under the MOs (includes fish and wildlife, water quality, cultural resources, public safety, and others). Across these general cost categories under the No Action Alternative, capital costs accounts for 23 percent of total annual system costs, O&M accounts for 45 percent of total annual system costs, and mitigation accounts for 31 percent of total annual system costs.

MO1 represents a relatively small increase in annual-equivalent costs when compared to the No Action Alternative. Under MO1 there would be an estimated increase of $21 million annually, or 2 percent compared to No Action Alternative (Table 3-308 and Table 3-309). This cost increase is driven primarily by construction of structural measures. Present value of the structural measure costs for MO1 structural measures are estimated to be $533 million. When amortized over the 50-year period of analysis, the annual equivalent cost is approximately $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).

the McNary project ($253.8 million in first costs for all structural measures at McNary), where a number of fish-related measures would be constructed, followed by similar fish-related measures at the Ice Harbor project ($114.2 million in first costs).[4] There would be slight changes to capital and O&M costs from the structural measures and operational changes under MO1, while fish and wildlife mitigation costs are expected to be similar to No Action Alternative (i.e., Bonneville F&W Program, LSRCP, CRFM, and the Reclamation ESA-related mitigation would continue). MO1 would also include additional mitigation measures as described in Section 5.4.1 and Annex B of the Cost Analysis appendix.

As shown in Table 3-308, MO2 is estimated to cost between $53 to $106 million more annually than the No Action Alternative (5 to 10 percent increase). Under MO2, power generation would increase and juvenile fish passage spill would be reduced. MO2 cost increases are driven by construction costs of structural measures estimated to be $1.4 billion (present values of the cost of the structural measures). Much of the increase in costs for the structural measures under MO2 compared to MO1 occurs at McNary (powerhouse surface passage first cost under MO2 is $889 million versus $158 million under MO1), where additional surface passage would include construction of a collection channel and dewatering facility. There would be related increases in capital and O&M costs from the structural measures and operational changes under MO2. If the operational measures under MO2 have a negative effect on fish, there could be an increased need for off-site mitigation funded through the Bonneville F&W Program (Bonneville 2019). Potential increases to the Bonneville F&W Program are estimated to range from the same as No Action Alternative up to $53 million above the No Action Alternative budget of $281 million. Funding decisions for the Bonneville F&W Program are not being made as a part of the CRSO EIS process. However, a range of potential F&W Program costs is included to inform the broader cost analysis. By analyzing a range of costs, Bonneville reflects the year-to-year fluctuations related to managing its F&W Program and acknowledges the uncertainty of both the magnitude of biological effects and the potential impacts on funding, including the timing of funding decisions. Future budget adjustments would be made in coordination with the region through Bonneville's budget-making processes and other appropriate forums, consistent with existing agreements. LSRCP, CRFM, and Reclamation ESA-related mitigation would remain the same as under the No Action Alternative. Some additional MO2 mitigation actions are proposed as described in Section 5.4.2 and Annex B of the Cost Analysis appendix.

Under MO3, total costs are anticipated to decrease between $159 and $54 million annually, or between 15.1 to 5.1 percent decline compared to the No Action Alternative (Table 3-309). The present value of the construction of the structural measures for MO3 are estimated to be $1.2 billion. Of the $1.2 billion, $994 million (or 77 percent) are costs associated with breaching the Lower Snake River dams. When amortized over the 50-year period of analysis, the annual equivalent cost is approximately $46 million ($35 million for the costs for breaching the Lower 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.

structural measures in terms of its impact on annualized costs under MO3, comparing the cost of completing MO3 over a 10-year timeframe, versus the two-year implementation assumption. Delaying and spreading out costs for breaching the Lower Snake River dams would result in a change in annual equivalent costs of $3.6 million (from $45.7 million with a two-year implementation to $42.1 million with a 10-year implementation schedule) or a 0.4 percent reduction in total annual-equivalent costs under MO3. This difference in cost ($3.5 million) represents approximately 8 percent of the construction costs of the structural measures and 0.4 percent of total annual-equivalent costs under MO3. The difference between a two-year and a ten-year implementation schedule does not warrant deviation from the two-year approach used throughout the study.

MO3 would result in a large decrease in capital costs ($32 million or 13 percent) and O&M costs ($79 million or 16.5%) across all projects compared to the No Action Alternative, with the largest decrease at the Lower Snake River projects (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) (Table 3-309). Upon the breaching of the LSR dams, Bonneville would no longer have an obligation to fund USFWS for O&M of the LSRCP facilities, estimated at $34 million. Bonneville's funding authority is directly tied to the operation of the LSR dams. However, the co-lead agencies recognize that there would be transitional needs that would be addressed. Additionally, the Bonneville F&W Program funding for offsite mitigation projects in the Snake River Basin would be reviewed and potentially adjusted. Any changes of this nature would be implemented over time as the effectiveness of dam breaching is observed, and would be done in consultation with fish and wildlife managers, regulatory agencies, and the Northwest Power and Conservation Council. Consistent with this, offsite mitigation projects for the other CRS dams would be reviewed and could be adjusted as operations change over time. As a result, Bonneville's F&W Program costs are estimated as a range: from the same as under the No Action Alternative to a 37 percent decrease, or a decrease of $105 million annually when compared to the No Action Alternative. Future budget adjustments would be made in coordination with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements. The CRFM costs would also decrease under MO3 by $1.0 million annually, while the Reclamation's ESA-related costs would remain the same as under the No Action Alternative ($14.3 million per year).

Additional mitigation costs to offset the adverse impacts of MO3 are estimated to be $45.7 million annually. The largest mitigation costs would occur at the Lower Snake River projects, including measures for vegetation, wildlife, wetlands, and floodplains; water quality; cultural resources; anadromous fish; resident fish; public safety; navigation and transportation; and other mitigation measures. Details on the additional mitigation measures are described in Section 5.4.3 and Annex B of the Cost Analysis Technical Appendix.

Estimated MO4 costs range from a decrease in annual costs of $55 million to an increase in annual costs of $50 million, or a -5.2 percent decrease to 4.7 percent increase compared to the No Action Alternative (Table 3-309). MO4 includes $1.2 billion (present value) for the construction of the structural measures, or $44 million annually. MO4 includes powerhouse surface passage measures as well as spillway weir notch inserts at all Lower Snake River, McNary and John Day projects (which are not included under the other MOs) along with several other fish-related measures similar to those included under MO1. There would be slight changes to capital and operating and maintenance costs from the structural measures and operational changes under MO4. Bonneville included a range of potential F&W Program costs to acknowledge the possibility that MO4 could provide biological benefits to fish and wildlife and that this could, in turn, reduce the need for some offsite mitigation funded by the Bonneville F&W Program. As a result, offsite mitigation projects in the Bonneville F&W Program would be reviewed and could be adjusted as operations change over time. As a result, Bonneville's F&W Program costs are estimated to range from no change from No Action Alternative to a decrease of approximately 37 percent, or approximately $105 million, annually. Future budget adjustments would be made in coordination with the region through Bonneville's budget-making processes and other appropriate forums and consistent with existing agreements. The LSRCP, CRFM, F&W O&M, and the Reclamation ESA-related mitigation would remain the same as under the No Action Alternative.

**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 |

**Table 3-309. Change in Annual-equivalent Costs under the Multiple Objective Alternatives compared to the No Action Alternative ($2019)**

| 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% |